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Editorial

Patterns of socio-technical change

There are different ways to look at the dynamics of socio-technical change. One way is to analyse the co-constitution of technoscience and society focussing on the practices of the actors involved. This is the perspective of Veronika Lipphardt and Jörg Niewöhner's paper about "Producing difference in an age of biosociality" and of Andreas Langenohl and Kerstin Schmidt-Beck's contribution "Technology and (Post-)Sociality in the Financial Market". Another way is to identify patterns of socio-technical change. In Uli Meyer and Cornelius Schubert's contribution "Integrating path dependency and path creation in a general understanding of path constitution" the authors develop a concept that integrates strategic (intentional) and evolutionary (emergent) aspects of path creation and perpetuation. Conversely, Jobst Conrad examines the impact of the social and institutional context on technological change. In his paper about "The role of public policy in promoting technical innovations" this context is shaped by traditional public policy which, however, uses new policy instruments.

Albeit the four papers differ with regard to their empirical focus and analytical approach they share the understanding that patterns of social practices materialize as socio-material alignments of human agency and specific socio-technical contexts.

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Technology and (Post-)Sociality in the Financial Market: A Re-Evaluation

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Abstract

The article takes issue with recent influential work on the paradigmatic relevancy of technologically induced modes of communication and sociality on the financial markets. According to Karin Knorr Cetina and Urs Bruegger, the technological infrastructure of the global financial markets engenders novel forms of sociality and social integration: intersubjectivity with non-present others and (post)sociality with (imagined) objects. The article differentiates these hypotheses by way of confronting them with results from interviews conducted with financial market professionals such as asset managers and financial analysts. They reveal that financial professionals attribute the role of technology a varying meaning and engage in divergent technological practices depending on their market positionality: while, for instance, intraday traders report on an intimate and quasi-social relationship with the technologically institutionalized "object" of the market, equity analysts display a more distanced stance toward the market and attribute the technological nature of mass communication (especially the real-time circulation of information) paramount importance. In conclusion the paper calls for a nuanced and contextualized understanding of the impact of technology upon changing social relations.

1 Introduction

This article attempts to evaluate some recent influential work on the paradigmatic relevance of technologically induced modes of communication and sociality in the financial markets. In particular it critically assesses studies presented by Karin Knorr Cetina and Urs Bruegger which argue that the technological infrastructure of the global financial markets engenders novel forms of sociality and social integration, namely intersubjectivity with non-present others and sociality with (imagined) objects. In the present paper these hypotheses, which are empirically based on guided interviews with foreign exchange traders and ethnographic studies in the respective organizations, will be re-evaluated and modified by our confronting them with results from our own empirical studies which we conducted with financial market professionals such as asset managers and financial analysts.

It is not our aim to reject the important work done by Knorr Cetina and Bruegger but rather to supplement and to re-contextualize it on a broader empirical basis. Knorr Cetina and Bruegger's research concentrates on respondents and organizational units concerned with the extremely fast electronic intraday trade in foreign exchange markets (Knorr Cetina/Bruegger 2002: 916-919). In this they are part of a general trend in sociological financial market research to base general hypotheses on the analysis of highly specialized professional profiles, and in particular of traders in bonds, financial instruments, or currencies (cf. Fenton-O'Creevy et al. 2005; Abolafia 1996, 1998). These sociological studies into the financial economy thus rest upon a categorization, which at times amounts to a compartmentalization, of professional profiles. In contrast to this tendency, the sample upon which our research is based comprises traders as well as financial professionals who, although operating in and through the financial markets, are

situated at a somewhat greater distance to the financial flows – i.e. financial market analysts, members of buy-side and sell-side research departments, portfolio managers, and constructors of financial instruments.

This re-contextualization of the arguments made by Knorr Cetina and Bruegger will lead to a re-evaluation of their theoretical and methodological generalizations. Although we agree with their arguments regarding very short-termed and rapid market transactions, we will challenge their generalization that financial markets, which they hold to be the most technologically advanced and globalized communicative level of infrastructure, resemble some sort of avant-garde in regard to the diffusion of "postsocial" forms of sociality (Knorr Cetina/Bruegger 2002: 945). The main thrust of this paper is the argument that the impact of technological infrastructure on modes of sociality can be more thoroughly understood if one takes into consideration the multiplicity of representations and imaginations of technology to be found in the statements and narratives of financial market professionals.

2 "Postsociality" in the Global Foreign Exchange Market

Karin Knorr Cetina and Urs Bruegger emphasize as paramount the significance of technological communications infrastructure for the institutionalization of contemporary social relationships. Empirically, this approach rests on investigations into the global financial markets and in particular the foreign exchange (FX) market to which the authors dedicated extensive field work in globally operating banks, document analyses and a number of interviews with FX traders and their managers. At the same time many of the arguments are extensions of more general hypotheses concerning technologically assisted and framed modes of action and communication in general, for example, the relationship be-

tween natural scientists and their objects of knowledge within the socio-technological setting of science labs (Knorr Cetina 1997, 2000): both objects of scientific investigation and financial markets are conceived of as "epistemic objects" in Rheinberger's (2001) sense, as both are "unfolding object[s]" (Knorr Cetina/Bruegger 2000: 152) whose meaning is not fixed but reveals itself only through a constant and open-ended process of investigation, negotiation and redefinition.

As already mentioned, the authors focus on a specific group among financial market professionals, namely FX traders. This group is defined as distinct from brokers, bond traders, portfolio managers or financial analysts in various ways. First, they and their departments are characterized as "institutional hybrids that are placed at the boundary between organizations and markets and that combine principles of both" (Knorr Cetina/Bruegger 2002: 913). This means that they are most directly exposed to financial market dynamics. Second, they trade directly with other traders and not, for instance, through the stock exchange or a broker. Third, thanks to state-of-the-art technological communications infrastructure, their trading takes place in a real-time mode and is processed as highly routinized virtual communication via computer screens. This leads Knorr Cetina and Bruegger to term this interaction between the traders and the FX market, in obvious allusion to fundamental work in microsociology, a "face-to-screen interaction" (Knorr Cetina/Bruegger 2002: 923).

The results and interpretations presented by the authors suggest that FX traders maintain specific and distinguishable forms of sociality with their colleagues as well as with the "object" of the market itself. The relationship between the traders results in a "global microstructure" (Knorr Cetina/Bruegger 2002): they engender social integration, norm-setting and norm-observation via face-to-screen interac-

tion which is experienced by the traders as intersubjectivity. For instance, traders oblige each other to put calls in order to keep the market liquid even though this might result in losing money. This allows the authors to distinguish their approach from the mainstream social-scientific argument that globalization leads first of all to the anonymous interlocking of the consequences of actions and the emergence of an apersonal "space of flows" (Castells 1996; cf. Albert et al. 1999; Strange 1986). This intersubjectivity with non-present others is paralleled by a sociality with the "epistemic object" (Rheinberger 2001) of the market when Knorr Cetina and Bruegger argue that FX traders imagine the market as a living being with its own rhythms, moods, and strategies, which makes it possible for them to engage in "sociality with objects". This form of interaction with such a living "subject-object" is made possible through the technological "appresentation" and materialization of the market in the computer infrastructure. Interacting with the market thus takes on an intersubjective quality through the self-presentation of the market on the computer screens and its instant upward and downward moves in response to one's own actions. The computer screens thus do not simply represent the market, but are this market in a very radical sense, which is why they can be engaged with through a quasi-intersubjective, "postsocial" relationship.

Interacting with the market, in short, engenders special ways of subjectivization and self-identification. Interaction with non-present others as well as with the object of the market takes on features of intersubjectivity and sociality between human subjects. The main underlying theoretical argument here is that the market can be treated by the FX traders as a "copresent other" (Knorr Cetina/Bruegger 2002: 940) because it is a fundamentally open-ended and evolving object that acts

and reacts seemingly in relation to one's own actions.

The theoretical foundation of this interpretation is the subject of further inspection in section 4 of this paper. At the present stage it is more urgent to focus on the theoretical and methodological generalizations that Knorr Cetina and Bruegger deduce from their empirical work. First, they propose to extend the meanings of intersubjectivity and sociality with objects as met in their work to a general sociological understanding of those terms. According to this proposition, objects are not to be seen as simple instruments or projection screens for social meaning because they can be treated as co-subjects in everyday life. Technical artifacts like computer screens and keyboards turn from instruments and media into interaction partners which allow the traders to subjectivize themselves (cf. also Latour 1996, 2000; Miettinen/Virkkunen 2005; Rheinberger 2001). Second, the authors claim that these forms of sociality with objects herald a more general tendency in the ways human beings interact with their environment and exist in relation to each other (Knorr Cetina 2005). Third, they regard their work as a contribution to general questions in economic sociology, as they show that market players are in no way rational *homines oeconomici* but are entangled within norm-oriented and reciprocal interactions with non-present others as well as within identificatory bindings with their object of attachment, the FX market.

The connecting link between these generalizations and the ground upon which they are erected is the argument that it is the technological communications infrastructure of the global financial markets and, as a consequence, real-time trade that makes global intersubjectivity and sociality with objects possible. We hold that this argument needs to be examined within the context of broader empirical research in order to be re-evaluated as

to its potential for generalization. In the next section two differentiations will be suggested: first, that the imagination of the financial market as subject-object is but one among at least two imaginations, and as such does not necessarily rest upon its embodiment in technological artifacts; and second, that the potential of technology to shape imaginations of the financial markets is by no means reducible to "face-to-screen" interactions.

3 Results from Interviews with Financial Market Professionals

The data pool of our analysis encompasses 30 guided interviews with financial market professionals conducted between May 2003 and July 2004 (cf. also Langenohl/Schmidt-Beck 2006, 2007; Langenohl 2007; Langenohl 2007a). The respondents work as financial market analysts, portfolio managers or constructors of financial instruments in banks located in Frankfurt/Main. The interview guideline included questions related to the recent financial market crisis, the respondents' professional biography and general structures of the financial markets. This dual approach, addressing the respondents as experts and as autobiographical subjects, encouraged them to switch between explicatory and narrative modes of clarifying their relationship with the financial market. The interpretation of these data draws a complex picture, challenging the investigator to approach the relationship between the professionals, the technological nature of the financial markets, and imaginations of the market in a cautious manner.

Accordingly, we attempt to investigate technology and its social meaning in its varieties as they surface in our respondents' narratives. First, we review cases which replicate the findings of Knorr Cetina and Bruegger in that they attest to the existence of technologically induced market practices that

generate the imagination of a "living" market and indeed give reason to talk about sociality with objects representing themselves in technologies (3.1). Second, we turn to some respondents in our sample who contradict those interviewed by Knorr Cetina and Bruegger – financial market analysts who operate at a certain distance from immediate market dynamics, use technology merely as a "toolkit", and maintain an imagination of the market entirely different from those observed in FX traders. We also examine the role of the media of mass communication through the eyes of our respondents, because their views make it clear that the technological structure of contemporary mass media – especially their capacity to instantly circulate information to a broad public – has a great influence on how financial market professionals make use of and participate in them (3.2).

3.1 Short-Term Trading: Technical Artifacts and Intersubjectivity with Non-Present Others

An attachment to technologically embodied objects reminiscent of that observed by Knorr Cetina and Bruegger can be found in our sample mainly with respondents who work in close proximity to the financial markets and must constantly rely on communications and information technology in their everyday work. This applies, for instance, to professionals who, alongside their obligations in financial market research, spend considerable time in trading and brokerage, but it can also be found in cases of portfolio managers who deliberately rely on short-term instruments like chart analysis or momentum analysis in making their investment decisions.

As mentioned above, these types of activity can be regarded as taking place in close proximity to the financial markets. The flow of information is continuous and gives a real-time picture of the financial markets' tendencies. This information is visualized

and appears on a number of computer screens which can be watched simultaneously. It is interpreted not so much as information engendering reflection but more as an imperative to act – that is, to trade. The imperative and, in this sense, performative meaning of technologically appresented financial market information is exemplarily indicated in the following sequences from our interviews:

"We got systems – if you see them next to each other you get 10 news per second from all over the world (...) this comes across instantly and the rates react (...) I can see it here it's coming – I got point and figure charts – that is, black pictures are coming I say o-o what's up? Immediately to the news and – I know everything, right? And the most important thing now is not to overreact." (F12w, pp. 9-11)

"If I see a movement I must instantly decide whether to jump on it or not". (A-H14w, pp. 22-3)

Much in line with Knorr Cetina and Bruegger's interpretation, the respondents seem to be inserted into a "timeworld" (Knorr Cetina 2005: 39) which obliges them to react instantly to very short-term movements in the technological communications and information infrastructure. This reaction cannot but manifest itself again when respondents manipulate technological artefacts, thus producing mutual dependency between the market and those trading: "instantly here the market moves up moves down you can see the losses or the gains." (F12w, p. 47) The interplay between the systems visualizing information and the professionals' practices, alongside the impression of mutuality and interaction that accompanies it, has three implications:

First, technical artifacts like the software visualizing the development of rates as charts appear to be aggregates of a market happening, showing the actions of all involved actors, their consequences and their interconnections. So, for instance, the chart is seen as "in fact only the image of what ahhm a human being can actually

stand" (F12w, p. 36). In this way, the market constitutes and presents itself as a collective actor (cf. also Knorr Cetina/Bruegger 2002a). It is ascribed motives and intentions which must be deciphered and understood, as when a professional trader tries to find out how the market's "hobby horse" is developing.

Second, the professionals experience themselves as continuously involved in the market precisely because they are able to trace their own actions and their consequences along with those of others within the market as collective actor. This involvedness also entails an aesthetic fascination with the epistemic market-object in addition to the emotionally charged attachment to it: "how beautifully you can draw lines and the market touches down exactly on that line..." (F12w, p. 39).

Third, the simultaneity of the sensual (visual) experience of the market and of one's own practices on that market produces an experience of intersubjectivity with non-present others and along with it a sense of belonging to an imagined life-world "market" constituted through the technological system (cf. also Knorr Cetina 1997): "the market touches down precisely on the line – and turns upward again – and – because everyone is looking at that – it works." (F12w, p. 39) Accordingly, intersubjectivity and belonging cease to exist as soon as the system no longer presents the market, which was what happened on 9/11: "Because simply between 20 positions there is no price anymore because nobody is doing anything..." (A-H14w, p. 22)

To sum up, our results are quite in line with those of Knorr Cetina and Bruegger insofar as they concern professionals who perceive themselves mainly engaged in short-term investments. These refer in their imaginations of the financial market explicitly and regularly to technological systems visualizing and in a certain sense producing the market, and see themselves

with their own actions and their consequences as an organic part of the market as a collective actor. Consequently, if the system crashes, the market disappears not just as a source of information but as a partner, a situation inspiring what might be termed *horror vacui*.

3.2 Long-Term Market Orientations: Reflexivity of the Market and the Use of Technology

In contrast to the views just analyzed, we now turn to the second group of professionals identifiable from our interview data: those who prefer not to operate within a short-term investment horizon but rather focus on long-term developments in their investment and research strategies. In our sample, this group is mainly represented by those who call themselves "fundamental analysts" and operate at a much greater distance from the everyday short-term developments of the financial markets.

This group differs from the one discussed above in two relevant aspects. First, they are not themselves engaged in the stock markets but are concerned with the analysis of "fundamental" business, micro- and macroeconomic data such as the turnover and the profit of a company, the development of the GDP, interest rates and inflation. They are expected to compile the analysis of these data into comprehensive reports intended either for external clients like institutional investors or for the investment departments of their own organizations. Like short-term oriented professionals, they rely on technological communications and information systems as well as in-house expert systems for the production of their reports, as these quickly become outdated. However, their relationship to technology seems to be of a rather instrumentalizing nature, comparable to how one might see a tool box. Technological artifacts thus function as instruments for conducting the work proper and are not experi-

enced as providing imperatives for action. On the contrary, they are seen as processing data that help the analysts to maintain a reflexive and distanced attitude toward the financial markets. Action in their case does not mean constant and continuous trade but the articulation of well-founded judgments about the probable development of this or that rate. The attitudes toward technology remain within the framework set by that goal: "it is all about pulling the right instrument out of one's toolbox at the right time and using it properly." (A11m, p. 29)

Fundamental analysts thus have no affective object relationship to technology, to which they also refer as "set of tools" or "analytical framework" (A3m, pp. 5, 11). Non-technological forms of obtaining information, like meetings with company board members or industry representatives, are generally valued more highly than the technical instruments, as are analyses of company or industry data. At the same time, analysts tend to differentiate themselves and their style of work from those colleagues, like chart analysts, who work in closer proximity to the market and rely more on the market dynamics themselves to make forecasts. These form their "own different sector" (A7m, p. 34) and are asked for advice only sporadically. Technological artifacts thus do not contribute to constituting an imagined community of financial professionals, as is the case for traders.

The second feature distinguishing the fundamental analysts from the traders and those portfolio managers who have a short-term orientation is the nature of their imagination of the market, which is closely related to their respective temporal horizon. As a rule, fundamental analysts make forecasts for several months up to one year, which implies that markets may actually deviate from their fundamentally justified base line without completely losing touch with it. The market thus is

imagined as "returning" over time from a deviation to its "normal" level: "if you look at it from a long-term perspective, since the middle of the 1990s we had moved away from the normal trend" (A4m, p. 4). This deviation from the norm and the ensuing return to basic standards vindicates the accuracy of the "fundamental" rules: "in the end, though, I think that the fundamental values always prevail. That means, also in the medium term." (A7m, p. 35)

This fundamental logic is regularly opposed in the interviews to the supposedly "irrational excesses" of the financial markets which are observed in so-called "bubble" phases or hypes. While the fundamental dynamics that keep the financial markets in touch with the developments of the "real" economy articulate the norm of market behavior, the deviation from that norm is associated with short-term "speculation", exaggeration and "psychological" (read irrational) factors. The following quotation from an interview with a fundamental analyst, who is discussing the recent downturn in the stock market, exemplifies the element of morality inherent in the confrontation between short-term and long-term dynamics as perceived by the respondents:

"What takes place here is a downward exaggeration on a massive scale – which eventually will be corrected, right? By now, all reasonable rules are still invalidated. And in the long run they do apply. Well of course the markets can so-to-speak deviate from the world of let's call it economic facts – but not in the long run." (A3m, p. 28)

In contrast to the imagination of the financial market as a living being following its own moods and rhythms, which is prominent among traders and more short-term oriented asset managers, the analysts interviewed imagine the market as a long-term law-like rational order based on fundamental economic data. At times, this order is given a metaphysical ontology, as becomes apparent in statements denying the possibility to fully grasp and un-

derstand the laws of the market: "the market – if you are engaged with it for some time, it forces you into humility." (A3m, p. 30) This hypostatization of the market, despite giving it a certain essence and even personhood, is a far cry from the imagination of the market as an "other" that one can be attached to and that enables novel forms of sociality.

A recent study on traders by Fenton-O'Creevy et al. (2005), combining psychological, economic and sociological viewpoints, distinguishes between two aspects of traders' professional everyday life, namely theories about "how the world works" and theories about "how to work the world", with the first being related to abstract knowledge about market laws usually acquired in university and the second referring to practical rules of thumb that structure action. As a result of our observations, though, it might be contended that for traders, short-term oriented asset managers and professionals working in close proximity to the markets in general, these two aspects tend to coincide, thus producing the imagination of a market-subject present in its technological manifestations. The technologically produced self-presentation of the market gives way to holistic views of it, where sense-making and the production of meaning directly from trading via the professional "technoscape" (Appadurai 1990: 8). In contrast to this amalgamation of practical knowledge and reflexive sense-making, "fundamental" analysts seem rather to keep both aspects of their work separate from each other. The instrumental aspect manifests itself in the strategic use of technological means, while the construction of meaning assumes the existence of an abstract law-governed market not subject to immediate experience. Therefore, for professionals working at a greater distance from the financial markets, their technological nature cannot produce new forms of sociality by itself.

It would be one-sided to say, however, that analysts and professionals with a long-term perspective do not see themselves exposed to the impact of technological infrastructure at all. This becomes apparent if one considers the importance that the professionals in our sample attribute to the influence exerted on the financial markets by the media of mass communication and information like TV, the press, and online information services. Thus, alongside the technologies that provide for direct exchange between professionals, the market and other expert systems, there may be other ways in which communications and information technologies structure financial market practices.¹

We shall briefly exemplify this, with reference to our interviews. The first example comes from an interview with a stock market analyst, who characterizes the significance of the media of

¹ Discussions in the sociology and political economy of the financial markets also highlight this dimension of the technological institutionalization of the markets, as they address technology primarily as communications and information infrastructure (cf. Strange 1986; Castells 1996; Albert et al. 1999). Many investigations into the financial economy have capitalized on the decisive role of such infrastructure in the institutionalization and maintenance of the global financial markets. For instance, Saskia Sassen (1991, 2005) has argued that what underlies those markets is a technological and organizational substrate concentrated in "global cities". This substrate is not confined to the information highways that circulate capital in a real-time mode, but also encompasses expert data systems and communications infrastructure linking banks with non-bank organizations such as law firms, advertising companies, and news companies. Communications and information infrastructure that serves to keep the financial markets working thus combines principles of what Arjun Appadurai (1990) calls technoscapes, financescapes and mediascapes, and consequently resists being reduced to the technical equipment that facilitates the (in a way atypical) direct communication among foreign exchange traders.

mass communication for financial analysis as follows.

"It ahm quite often happens that – in the morning in the newspaper there is an article referring to an enterprise – ahm hm hm then you need to comment on that and you need to – your own point of view – is there some truth in a certain speculation or not – is it taken out of the blue – or not – hh you need to comment on that – and therefore we naturally need – to intensively know in which way the media refer to our reports." (A15m, p. 3)

From this example it becomes evident that the practice of using information circulated in mass communications and information technology is bound up with reflexive participation in the initial generation of that information. The practices of using information technology reported by our respondents resemble a mode of coming to terms with the reflexivity often attributed to the financial markets in sociological theory. This reflexivity, in its structural dimension, consists in the fact that the dynamics of the financial markets are conditioned by assumptions about how these dynamics work and assumptions about the assumptions of other market participants. Studies in financial market sociology have confirmed that market participants make use of their own actions and the responses these generate in order to orient themselves in the reflexive market environment (Clark/Thrift 2005; Fenton-O'Creevy et al. 2005; MacKenzie 2005). Coinciding with the findings of other investigations, however (Clark/Thrift/Tickell 2004), the analysts interviewed in our research study see the flow of information in the mass media as of paramount importance to the reflexive development of the financial markets. This is exemplified by the following statement from an equity market analyst:

"Well we rather tend to perceive the media as contra-indicator. That is – if for example you see certain companies or ahm company CEOs on the front pages of international magazines – now – then you know that you face a turning point." (A3m, p. 8)

Information about financial market processes, once circulated in the mass media, is not just descriptive but affects the developments it sought to describe. It is a typical example of what Anthony Giddens (1994) termed "social reflexivity" – information about social processes is invalidated (and policies aimed at steering them frustrated) precisely because it is appropriated by those driving the processes. The way that the respondents report how they make use of information technology, along with their reflections upon their own role in generating information which is instantly circulated, indicates that they appropriate the technological structure of mass communication in order to get a grip on the social reflexivity of the financial markets. Thus, their practices of cautiously using the media replicates on a cultural level the media's structural reflexivity which is grounded in their specific technological institutionalization. In other words, their capacity to instantly and grossly circulate information undermines its descriptive power.

Knorr Cetina and Bruegger maintain that there is a link between the technological institutionalization of the financial market and their ability to produce and allow the emergence of new forms of sociality with objects. We have supplemented this argument by way of two observations. First, not all financial professionals and market participants refer to the market as a sociable other, and not all of them use technological and communications infrastructure as a means to establish object-centered sociality. Second, the technological architecture of media of mass communication, and in particular their capacity to circulate information in virtually no time, is reflexively "built into" the practices professionals deploy in order to come to terms with financial market dynamics.

Our critique of Knorr Cetina and Bruegger is thus a twofold one. While their claim that sense-making prac-

tices on the financial markets are exclusively determined by technology is too bold, their implication that it is primarily or even exclusively electronically institutionalized trading where technology affects such practices is too restrictive. In order to estimate the theoretical importance of these findings, though, it is necessary to come back to Knorr Cetina and Bruegger's theoretical argumentation and to inspect it more closely, which will be undertaken in the next section.

4 Short-term and Long-term Practices and the Attachment to the Market

Knorr Cetina and Bruegger's theoretical argument is dense and variegated. The authors do not confine themselves to basing their hypotheses on just one theoretical paradigm but make reference to three theoretical approaches in order to theorize intersubjectivity among non-present others and sociality with objects. For instance, they refer to Jacques Lacan's concept of an economy of desire constituting the unconscious relationship between two subjects to characterize how traders subjectivize themselves in relation to the market (Knorr Cetina/Bruegger 2002a; Knorr Cetina 2005). On the other hand, their notion of "face-to-screen-interaction" is explicitly based on George Herbert Mead's elaborations on "taking the attitude of the other" as a fundamental human capability and a cornerstone of intersubjectivity. However, in the context of the present paper it seems most promising to review the authors' reference to Alfred Schutz's notion of intersubjectivity, because this reference is most crucial to their argument, permitting them to characterize intersubjectivity with non-present others and sociality with objects (Knorr Cetina/Bruegger 2000, 2002).

Schutz' conception of intersubjectivity is important for the authors because of its implications concerning the tempo-

ral coordination among traders and between them and the market. According to Schutz, a "we-relation" (Schutz 1964: 55) necessarily presupposes face-to-face-interaction, since the defining feature of intersubjectivity – the simultaneous orientation of two actors toward each other's actions – necessitates their co-presence in one spot at one and the same time. This mutual orientation toward each other's actions and motives has as its sociological substrate the intersubjective interlocking of two types of motive: "because motives" and "in-order-to motives". In-order-to motives can be described as action incentives which, due to their habitualization and routinization, cannot be reflected upon while they are in play (much like Mead's "I"). It is only in retrospect that they can be reflected upon, in which state they appear as rationalized because-motives.

In the financial markets, then, traders manipulate their keyboards *in order to* make a certain deal, but this capacity to affect the market via a technical artifact is not accessible for reflection while in use. Instead, traders would later explain their actions by saying that they manipulated their instruments *because* making that deal at that time appeared to them to be a promising move. Intersubjectivity, according to Schutz, consists of a transformation of one's own in-order-to motives into the because motives of the other and vice versa; that is, it presupposes that one's own implicit motivations become explicit and meaningful through interpretation by others and ascription to others' actions. In Knorr Cetina's argument it is thus plausible to talk about intersubjectivity on the financial markets, in that the traders interpret their own actions as reactions to the motivations ascribed to non-present others or to the market itself (Knorr Cetina/Bruegger 2002: 927, 2000: 162-3). They constantly question what the market "wants" and see their actions as reacting to the thus interpreted and

constructed desires of the market as it appresents itself onto their screens.

This argument rests on the idea that the intertemporality between the traders and the market is central. It consists of three dimensions: synchronization, that is, the sequential interlocking of in-order-to and because motives; continuity, guaranteeing an unrestricted sequentiality and leading to the impression that one shares the "same time" with the market; and immediacy, which means that one action (or even the lack of an action) can instantly be interpreted as a reaction to a preceding action (Knorr Cetina/Bruegger 2000: 162-163, 2002: 921-924). In this use of the term intersubjectivity and its grounding on the three dimensions of intertemporality, it is indeed plausible to talk about intersubjectivity with non-present other traders as well as about sociality with the imagined object of the market. The reference to formal phenomenology thus permits the authors to claim intersubjectivity as one major dimension of sociality and socialization on the financial markets. They sum up their argument in the following way:

"[S]ynchronicity refers to the phenomenon that traders and salespeople observe the same market events simultaneously over the same time period; continuity means they observe the market virtually without interruption, having lunch at their desk and asking others to watch when they step out; and temporal immediacy refers to the immediate real time availability of market transactions and information to participants within the appropriate institutional trading networks." (Knorr Cetina/Bruegger 2000: 162)

This statement, though, also makes it clear that the link between the formal phenomenological notion of intersubjectivity and the hypothesis of sociality with objects is restricted to *very short-termed* actions in the markets. Without the temporal specifications of synchronicity, continuity and immediacy, which owe their existence to the technological character of the FX markets, it is much harder to envisage intersubjectivity with non-present others or

sociality with objects. It is only by way of constant trading at very short notice that the quasi-interactive bond between traders and markets can materialize. Obviously unaware of this circumstance, Knorr Cetina and Bruegger extend their argument to other social mechanisms of financial market coordination in that they also observe synchronicity and continuity in, for instance, the transferring of order books between time zones or the simultaneous reaction of traders all over the world on the occasion of important calendar dates (for instance, before the end of the financial year, Knorr Cetina/Bruegger 2000: 163, 2002: 928-932). These occurrences, however, have strictly speaking nothing to do with sociality with objects in that they are not technologically induced forms of sociality which have the power to extend the cohesion of micro-structural bonds to global networks and imagined objects. Instead they belong to other phenomenal categories: in the case of order books, they are processes of coordination within transnational companies (Clark/Thrift 2005; Thrift/French 2002; Power 2005), while the joint orientation toward fixed calendar dates rather resembles a quite classical case of the ritual construction of collective identity in imagined communities (Anderson 1987; Spillman 1997). These forms of social coordination and imagination, which Knorr Cetina and Bruegger associate with their general argument of (post)sociality with the market, should thus rather be analyzed as quite traditional forms of sociality. They also ought not to distract attention from Knorr Cetina's and Bruegger's core argument: that postsociality in the financial markets, due to real-time reciprocity and the imagination of the market as a "time-world" in its own right engendered by high-performance communication infrastructure, is grounded in technology.

It is this argumentative kernel that the empirical results presented in the pre-

ceding section partially contradict. These results show that the imagination of a market as a co-present time-world with which the professionals literally interact is only one among at least two imaginative possibilities. Depending on their market proximity or distance, some professionals maintain an imagination of the market which is opposed to a self-sustaining timeworld in terms of temporality, namely that of the long-term rational and efficient market following eternal laws which compensate for and outweigh its short-term dynamics. Most of the respondents interviewed actually take a position between these two poles of market temporality. What is especially important for a contextualization and re-evaluation of Knorr Cetina and Bruegger's theoretical argument – that the sociality with the imagined object of the market is grounded on synchronization, continuity and immediacy – is the empirical finding that the imagination of the long-term rational market is diametrically opposed to all those dimensions of short-term temporal coordination. The imagination of the rational market thus articulates a threefold denial of sociality with imagined objects (in each of the three Schutzian dimensions).

Synchronization

In the first place, the long-term rationality and efficiency of the financial markets, which couples their development to that of the productive economy, never reveal themselves to the involved subject in real time, but presuppose either a representation of the past or an extrapolation into the future. The rationality of markets can never be experienced in the "contemporaneity of an event" (Knorr Cetina/Bruegger 2000: 922) but instead resembles a fiction cast into the future or the past which gains its plausibility precisely from its resistance to validation or falsification in the present. This fictive understanding of rationality is clearly evident in the following se-

quence from an interview with a financial analyst:

"looks like the markets, the investors, it's like there's some sort of collective ahm collective unit which surely tends to overreact but on the other hand doesn't assess things that badly, even those things which the analyst in the short run underestimates and doesn't assess correctly and is surprised by some movements, which of course afterwards turn out to be correct." (A2m, p. 22)

Continuity

Secondly, this fiction of long-term rational and efficient markets does not presuppose a continuing interaction in or with the market but can be maintained at a distance from the markets. Indeed, there is reason to assume that it might depend on a greater distance from the market than that associated with FX traders. This is illustrated in an interview with an asset manager who comments on his bank's decision to refrain from exploiting the financial turbulences on 9/11 for short-term investments of a speculative character, his argument being that the rationality of the market might be strengthened precisely by abstinence on the part of institutional investors from getting involved in short-termed investment strategies:

"basically we don't tend to – let's say exploit overreactions. As a global player in this area we rather should ahm try to pour oil on troubled waters here and there. ... that we actually have receded to a relatively neutral position... that is ahm we didn't do anything anymore." /F5m, p. 7)

Immediacy

Finally, as has already been mentioned, the long-term rationality and efficiency of the financial markets can never be immediately experienced by the subject in his/her market life-world, but, almost by definition, must remain remote and abstract.

To sum up, the "attachment" to the long-term rational and efficient market is grounded not on sociality with (imagined) objects appresenting themselves in technological artifacts but on the self-ascription to a sort of "imag-

ined community" in Benedict Anderson's sense (1987) which resists being experienced in the subjects' life-worlds. It also helps the long-term oriented professionals to distance themselves from strategies and professional groups operating at very short notice, for instance from, as one respondent put it, the "die-hard futures traders", who are represented as belonging to a different tribe. The imagination of the long-term rational market is therefore to be conceived of not as a fantasized "unfolding object" with which the professional subject can engage in a postsocial relationship but as a professional fiction or a counterfactual norm that serves to construct a professional identity through self-ascription to a rationalized principle and through the exclusion of those not adhering to it. The use of Schutz's elaborations to characterize the relationship between subject and market as intersubjective and sociable, which allows Knorr Cetina and Bruegger to discard the notion that normativity structures sociality, thus is more suitable for very short-term market action and the resulting emergence of the imagination of a market timeworld. However, in order to grasp alternative ways in which technological structures and dynamics channel professional practices of sense-making, like those of long-term oriented professionals reported on above, one has to take into account that norms (even if counterfactual) still do play a role in the financial markets. This leads us, in a final argument, to a theorization of the notion of normativity and its implications for approaches to the technological embeddedness of financial markets.

5 Norms, Imaginations, and Communications Technology in the Financial Markets

The idea that the normative mode of coordinating financial market action is outdated does not belong exclusively

to the postsociality argument. Recent system-functionalist work on the financial markets also maintains that the markets, as part of a post-industrial society whose defining feature is its reflexive grounding on knowledge processes and their frame conditions, shift from a normative mode of regulation (e.g., through laws and law-like regulation) to a cognitive one (for instance, through negotiations between legislators and financial market participants). According to this argument, "normative arrangements of (inter)national economic policy are being replaced by structures, processes and regulation systems that incorporate the risk of a purely cognitive orientation to price and market fluctuation" (Strulik 2006: 17; cf. also Willke 2006). This is an application of the more general hypothesis of modernization theory that normative modes of integration prove increasingly ineffective in steering societal subsystems which largely follow their own semantics (Luhmann 2000). Knorr Cetina's and Bruegger's studies are based on the same conviction that contemporary societies cannot be held together through reference to shared norms, and spell out its consequences on the micro-level of interaction and intersubjectivity. The reference to Schutz in their studies is thus not accidental. It serves not only to argue for the possibility of technology-induced sociality with objects but also, on a deeper level, to discard the meaning of norms in the constitution of interactions and intersubjectivity in general.

This becomes clear if one takes for a moment the theoretical counterperspective that communication is characterized by its potential to be developed into a meta-communication, i.e. a communication about communicative acts (Watzlawick/Bavelas/Jackson 1967). This necessarily implies the negotiation of norms and their validity and meaning because linguistic symbols are prototypical of social norms (cf. Habermas 1987). From this

perspective it might be argued that so-called interactions between traders and the market are deficient because they lack the capacity to be complemented by a meta level. There is no such thing as negotiation with the market. On the contrary, what behavioral finance describes as "herd behavior" – people's psychological vagaries and insecurities that drive them into a quasi-instinctive behavior of imitating each other (DeLong et al. 1990; Froot/Scharfstein/Stein 1992) – looks from a sociological viewpoint like abortive communicative interactions and failed procedures of social coordination. The thesis of technology-induced sociality in Knorr Cetina and Bruegger's approach, it might be suspected, is predetermined by their implicit reference to technology as "epistemic objects".

Still, the interpretation that acting and trading in the financial markets still has very much to do with the enactment of social norms can actually be deduced from Knorr Cetina and Bruegger's own studies. The hypothesis of the "global microstructures" engendered through face-to-screen interaction between traders says nothing else than that traders do obey certain norms that cannot be reduced to the aim of increasing one's own profit, because they have to do with the normative imperative of guaranteeing reciprocity in order to keep the markets working, to enable other traders to make their trades etc. (Knorr Cetina/Bruegger 2000: 924-8; cf. also section 2 above). For Knorr Cetina and Bruegger, the meaning of this finding has a role mainly within their major frame of reference, that is, the technological nature of FX trade and the new forms of sociality it is supposed to engender. For us, this evidence constitutes a call to address the relationship between norms, technology, and market imaginations.

Communications and information technology as well as the technological expert systems that serve to make the

financial markets work are heterogeneous. To cope with this diversity, it seems useful to revisit the classical sociological notion of the "norm". According to such eminent scholars as Ralf Dahrendorf (1964) or Helmuth Plessner (1985 [1960]), a norm is an expectation that differs from other kinds of expectations in two crucial ways. First, if normative expectations are not fulfilled, it is usually possible to "sanction" the offending party. Thus norms refer to *power differentials* within society. Second, unlike cognitive expectations, normative ones will be maintained even if they are not fulfilled because the disappointment of the expectation is ascribed to the person trespassing against it and not to an error in one's own expectations. Therefore norms can also be related to a highly effective *orientation function* that they fulfill even if not obeyed.

This twofold definition of norms, when applied to the dynamics of the financial markets and their technological substrate as addressed in this paper, reveals that the first and second characterization of norms can be respectively aligned with the different time horizons and uses of technology found in professional agency on the markets. Direct trade between market participants in a real-time mode obviously gives rise to norm-obedient behavior because it is possible to sanction anyone who deviates, that is, to exert power over him/her. Knorr Cetina and Bruegger state that if market makers do not conform to the reciprocity norm, they face negative sanctions from other traders in the form of discontinued trade. Employing the term "norm" in this context highlights the sanctions and the social power that norms are equipped with. This characterization of norm-obedient behavior on the financial markets is in line with investigations into more privative real-time exchange practices found in the global technoscape, namely Internet exchange forums. Their main point is that the Internet will never be the

norm-free area that many theorists associate with it, arguing that people engage in exchange practices which are based on reciprocity as the basic mode of normativity with the functional aim of *reintroducing* the possibility of normative expectations into communications-technological settings which, in principle, can do without them (Slater 2002).

Market distance and a certain instrumental attitude toward communications technology, which is specific to professionals not directly involved in trade, is accompanied by a sort of normativity largely leaning toward the second feature of norms, namely that they are preserved even if not adhered to. This aspect of norms, which forms the basis of the rational market imagination, may be termed normative counterfactuality. It is ultimately grounded outside market dynamics and erected against their technological institutionalization. Here it is not the communications and information infrastructure that lends itself to the diffusion of reciprocity norms, as with short-term oriented financial professionals, but, on the contrary, the expectation that markets will be rational and efficient despite the irrationality and hectic pace that real-time communications and information technology imposes on the financial economy. Imaginations of the market thus become a ground for probing adequate uses and understandings of technology, not the other way round. Therefore the counterfactual norm of market rationality is not to be challenged by technologically induced market dynamics. What is more, the fact that for financial professionals there is hardly any possibility to sanction those who do not adhere to that norm is precisely what gives it its imaginative and sense-making power. What is highlighted by the use of the notion of normativity in regard to the assumption of rational markets is the orientation function of norms for financial professionals

against all technological odds, and contrary to any systemic imperatives.

To sum up, our results indicate that it might be worthwhile to engage in a discussion on the role of technology in the context of normativity, not because technology by itself invalidates the working of social norms but because it recasts their sociological meaning.

6 Conclusion: Re-evaluating Technology-Induced Sociality

In this paper we have argued that the aptness to generalization of the consequences of technological infrastructure in regard to modes of sociality on the financial markets can be more thoroughly understood if one takes into consideration the multiplicity of representations and imaginations of the financial markets that professionals maintain. In particular, we have demonstrated that one encounters at least two representations of the financial markets at work in professionals' narratives: a short-termed market which appears as a living being with its own rhythms and moods, inviting participation in its temporal and spatial self-representation; and a long-termed market to which is ascribed a mode of rationality and which is the ultimate focus of some professionals' self-concepts, although its efficiency transcends the immediate professional life-world experience and insofar remains fictive. This complicates the picture drawn by Knorr Cetina and Bruegger in regard to the generality of postsocial relations in contemporary societies. While they argue that those relations no longer require adherence to shared norms and thus meticulously fit post-traditional societal settings, we maintain not only that norms are inherent to short-term trading actions, but also that the rational abstraction of the efficient market is precisely the establishment of norms, albeit fictive and counterfactual ones. This finding, which rests on the function of the rational abstraction of the efficient mar-

ket as a counterfactual norm, suggests that normative structures are at work in a site which has been rightly characterized as one of the most technologically imbricated and by virtue of that, most socially and culturally disembedded: the global financial markets (Baudrillard 1992, 2000; Castells 1996; Albert et al. 1999).

The role of technology in this site must therefore be discussed not only in regard to its tendency to alter modes of sociality or to herald society-wide postsocial developments. Instead, we opt for a discussion of the potential of technology not to invalidate social norms, but to recast their meaning. In this respect, there are two main conclusions to be drawn at the end of this paper.

First, communications and information technology, insofar as it forms part of social practices, not only attests to the importance of object relations in contemporary societies, but may also serve to extend the spatial and temporal scope of norm diffusion. The "global microstructures" that are part of the financial markets promote reciprocity norms beyond face-to-face social situations across the globe. It is as if the fluidity and apparent anomia of the virtual networks were being fought back through the materialization and diffusion of social norms (cf. Slater 2002: 228-9).

Second, technology alone does not shape social practices unless placed within social contexts and cultural orders of preference. For instance, the ways in which financial professionals orient their action with respect to the media of mass communication cannot be understood without taking into account that they experience them as part of the *economy*. Reflexivity thus occurs not only as a consequence of real-time modes of diffusing information but also because people *expect* it to direct other people's *economic* actions. In fact, real-time interaction and self-subjectivization on the FX market

is quite different from that in Internet chat-rooms, although the technological systems enabling both practices are comparable to each other. While the *general* impact of technology on social relations and societal integration should not be taken from the agenda of Science and Technology Studies, it is necessary to bear in mind that technological practices are, first of all, related to *specific* contexts and problematics.

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**Integrating path dependency and path creation in a general understanding of path constitution.
The role of agency and institutions in the stabilisation of technological innovations**

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Abstract

Path dependency as it is described by Arthur and David portrays technological developments as historically embedded, emergent processes. In contrast, Garud and Karnøe's notion of path creation emphasises the role of strategic change and deliberate action for the development of new technologies. In this article, we integrate both concepts into a general understanding of path processes which accounts for emergent as well as deliberate modes of path constitution. In addition, we distinguish between three consecutive phases of technological path developments. Both conceptualisations are used to create an analytical grid against which empirical cases of path processes can be matched. Based on this general understanding, we further outline how concepts from science and technology studies and institutional theory can help to elaborate the role of deliberate action and emergence in the stabilisation of technological paths over time.

1 Introduction

The message of path dependency appears to be simple: once you're on you probably can't get off. First developed to describe technological developments (David 1985; Arthur 1989), such a reading of path dependency is now widely understood as a plausible argument to describe inertia, stability, and irreversibility in a broad range of contexts (see Mahoney 2000; Greener 2002; Ackermann 2003; Beyer 2005). The broad application of path dependency has also inspired discussions of some of its underlying ideas, like contingency and non-ergodicity (David 2001), as well as critical notions like mindful path creation (Garud/Karnøe 2001). In this paper, we will limit ourselves to the analysis of technological paths and will not discuss the literature on institutional, political or historical paths or other forms of path dependency. We would like to contribute to this specific discussion by revisiting key concepts from path dependency, relating them to later ideas about path creation, and adding ideas about agency and institutions for our conception of path constitution.¹

For this purpose, we suggest that the reference to technology in the original concept of path dependency as it was made by David ("technological interrelatedness") and Arthur ("competing technologies") should be taken seriously. At the same time a broader – primarily sociological – theoretical framework is needed in order to explain the development of technological paths. This article explores how the

innovation of technologies can be understood as a process that is shaped by emergent processes which are more or less beyond the control of actors, as well as by active engagement, i.e. mindful contributions of powerful actors. We draw on the established concept of path dependency in order to account for emerging stabilities and seek to expand its scope by invoking the more recent notion of path creation (Garud/Karnøe 2001) to allow for elements of strategic change and deliberate action. In order to bridge the gap between the two perspectives on path processes, we aim for a general understanding of path constitution which does not describe emergence and deliberate action as contradicting explanations, but looks towards describing them as two ends of a continuum. Subsequently, a general understanding of path processes as showing properties of both emergence and deliberate action lends itself towards an elaborate description of different technological innovations.

In chapter two, we first revisit the general conceptual ideas of classic path dependency reasoning and then refer to the recent concept of path creation. Following this brief discussion, we integrate these two analytic frameworks into a broader concept of path constitution. The analytical framework of path constitution is mainly intended to provide an informed perspective in order to distinguish between multiple empirical cases of technological developments. In chapters three and four we then argue for the incorporation of more elaborate models of agency and institutions into the concept of technological paths. We do so by referring to concepts from science and technology studies (STS) and new institutional theory. With our discussion of agency and institutions we especially seek to further our understanding of the processes of stabilisation at work in the constitution of technological paths. We conclude with a summarising discussion of our general understanding of

¹ This paper is based on Uli Meyer's ongoing dissertation research on the innovation of Advanced Driver Assistance Systems in the automobile industry and on Cornelius Schubert's work in the research project "Path-Creating Networks: Innovating Next Generation Lithography in Germany and the U.S.", funded by the Volkswagen Foundation and supervised by Jörg Sydow and Arnold Windeler. Previous ideas have also been published in a working paper (Meyer/Schubert 2005).

path constitution, pointing out its key characteristics as well as sketching out further issues that should be discussed in more detail.

2 A general understanding of path constitution

2.1 Path dependency

David and Arthur developed the path dependency concept to propose a market diffusion model of technology which takes into consideration the historical embeddedness of economical processes. Instead of assuming technology to be optimal by definition, as it is done by neo-classical economic theory, the dominance of certain technological designs is explained by historical processes. Efficiency is not seen as the central reason for technological developments, therefore technologies are not expected to be optimal in every case.

The path dependency concept describes technological developments as being sensitive to initial conditions and influenced by processes which are probabilistic in nature. Triggered by *small events* (Arthur 1989: 118), inconspicuous random differences in the beginning of a development can lead to very different results later on. Such small events can be, for example, unexpected external incidents or the sequence in which new buyers choose between competing designs of a new technology. Because of the massive impact such small events can have, technological success is described per se as unpredictable.

This unpredictability however is only true for the emergence of a new technology, i.e. before a technology becomes a quasi-standard. Once a technology is established, the development becomes predictable or even irreversible. This is caused by *increasing returns* (Arthur 1989: 116) which manifest in a variety of processes. If increasing return processes are at work in the development of a specific tech-

nological design, every advance of this specific design leads to further advances. Certain developments, once started, grow stronger out of themselves. Arthur for example mentions "learning by using", "network externalities", "scale economies", "informational increasing returns", and "technological interrelatedness" (1988: 591).² In this way, a small advantage in the beginning probably leads to the total dominance of one design. Accordingly, further diffusion of this technology is not just predictable but also irreversible.

In case a technological option becomes irreversible by virtue of increasing returns, a technological path is *locked-in* (ibid.: 334). David assumes that only *external shocks* (2001: 26) can change a technological path, once it is locked-in. In line with path dependency's probabilistic reasoning, a lock-in occurs without any actor planning it. It merely emerges over time because of small random events at the beginning of a new technology design and the increasing returns, which were triggered by these events.

Especially Arthur has developed elaborate formal mathematical models to describe this idea of technological stabilisation as being sensitive to initial conditions and emphasised the probabilistic properties of such processes (1989). Behind these reduced formal mathematical models of path evolution, technological development is seen as something very complex. It is not goal oriented, it is not reversible, it depends on uncontrollable events, and

² The idea of increasing returns again contrasts with neo-classical theory, which is based on the assumption of decreasing returns. In contrast to increasing returns, they allow to making predictions based on mathematical models. Accepting increasing returns to be an element of economic processes results means the end for a lot of micro-economic forecasting models. This is one reason why the path dependency concept met heavy opposition in the beginning (Waldrop 1992).

there are many mechanisms which can lead to increasing returns and lock-in. But despite this perspective on technological development as being extremely complex, the concept is based on problematic simplifications:

1. Actors are thought to behave rationally in the sense that they always choose the technology which is best suited for them. However, technological paths are the result of an emergent evolution behind the backs of the actors.
2. Also, increasing returns and lock-in are emergent processes, which are not and can not be the result of deliberate planning and mindful action.
3. Once a path is locked-in, only external shocks can break it.

Subsequently, we suggest that several notions of the path dependency concept require modifications. Increasing returns, for example, is too narrow a definition of a more general phenomenon: self-reinforcing mechanisms. It is not just economic forces which stabilise an emerging path but social ones too. In addition, it is disputable if a lock-in can ever be as complete and irreversible as Arthur assumes it to be. A more general weakness of the concept is the very simple actor model. On the one hand, the only relevant actors are buyers who are conceptualised as fully rational individuals. On the other hand, actors are not considered to influence the shape of the competing technologies – at least not in the formal models. That is not a satisfactory perspective taking into consideration, for example, the enormous efforts companies undertake to promote their own standards and technologies (for a discussion of VHS winning over Betamax, see Cusumano et al. 1992).

In general we see the elegance of path dependency as argued by David as well as Arthur in the use of neo-classical assumptions about the individual actor to describe processes that can not be

explained by neo-classic economic reasoning, e.g. the persistence of suboptimal technological solutions. David and Arthur point out that suboptimal technological solutions do not emerge due to a lack of individual optimal choices but because of them, and that this is especially true in conditions predicted by market economics. However, the mechanics of increasing returns rely on a relatively stable market structure. Otherwise the described increasing-return mechanisms would not work. This only explains path dependency if technology is introduced into such a stable frame of reference, e.g. a consumer market filled with profit-optimising actors, but it says very little about the initial condition of choice in which the technologies themselves are shaped. In terms of Arthur, these conditions are reduced to mere chance processes like small events, with no actors having control over them. This reduction can not sufficiently grasp the complex interrelations and agency of artefacts, collectives of actors, and institutions in organised innovation processes.

2.2 Path creation

The concept of *path creation* by Raghu Garud and Peter Karnøe (2001, 2003) offers solutions for some of the problematic simplifications of path dependency. On the one hand, it is based on the same fundamental assumptions: technological development is historically embedded, it may stabilise and – if this happens – it is hardly reversible. On the other hand, and in contrast to path dependency, probabilistic events are not assumed to be the primary explanation for technological path development. Instead, the authors stress the relevance of strategic, deliberate and mindful *action* of actors. Actors initiate the development of a path through *mindful deviations* from known procedures or rules (Garud/Karnøe 2001: 6). Mindful deviation is not a solitary act, but a long lasting process of continual path creating and stabilising activities. For ex-

ample, the development of the post-it notes lasted for more than ten years before the path was actually stabilised.

In their articles of 2001 and 2003, Garud and Karnøe give two very different examples of path creation: the development of the post-it notes at 3M, and a comparison of wind turbine development in Denmark and the US. In the case of the post-it notes, they describe how the discovery of a "glue that does not glue" (*ibid.*: 14) leads to the development of the well known post-it notes. The authors focus on the role of actors in shaping an emerging path, especially on Spencer Silver, the "creator" of post-it notes, who mindfully deviated from 3M's routines of developing stronger kinds of glue. Borrowing concepts from Actor-Network-Theory (ANT), they describe, how he managed to "mobilize" different resources like "minds", "time", and "molecules".³ In contrast to the empirical examples presented by Arthur and David, they also focus on the pre-market phase of the innovation. The path of the post-it note is created before the product is introduced into the market.

In their second empirical study, Garud and Karnøe (2003) compare the development of wind-turbines in Denmark and the United States. In contrast to the strong emphasis of the individual entrepreneur in the post-it example, Garud and Karnøe stress the mindful, yet emergent, character of technological development. They describe "entrepreneurial agency as distributed across multiple actors" (*ibid.*: 277). The path is stabilised by the accumulation of inputs from multiple actors who can influence, but never fully control the process. They portray the two different

countries as examples for different strategies to establish a technological path: bricolage in Denmark and breakthrough in the US. Bricolage describes the emergent co-shaping of technology and actors. There were no grand plans regarding what wind turbine energy production was supposed to look like in the end. Rather, distributed actors offered inputs to generate a virtuous learning circle. Breakthrough, in contrast, describes long-term planning in combination with a competitive market structure. Because of the latter, and the resulting lack of cooperation between central actors, a stable path did not develop in the case of the US wind turbine industry.

Garud and Karnøe emphasise, that a path can be the result of deliberate strategic activities of a multitude of actors. Nevertheless, it is not guaranteed that the path is in any way consistent with the intentions of the actors responsible for its development. They refer to Giddens' structuration theory to emphasise that the developing path is medium and result of the activities of actors at the same time (*ibid.*: 281). Thus, the problematic simplifications of the classic path dependency concept are addressed by highlighting the deliberate aspects in path creation:

1. Powerful actors can strategically influence the development of a path. They can shape the path, while over time they are themselves shaped by the path.
2. Increasing returns and lock-in are subject to deliberate actions and tied in with broader social dynamics.
3. The creation, but also the ending of a path may be caused by deliberate actions which do not necessarily have to be external.

However, path creation says very little about the development of a technological path after it has been created and the question remains how the two conceptual approaches can be inte-

³ Because of the extensive application of the term "mobilizing", it is used to describe such different things as "mobilize a collective to identify 'a problem for his solution'" (mobilizing minds: Garud/Karnøe 2001: 14-18) or "apply [the glue] directly to paper" (mobilizing molecules: Garud/Karnøe 2001: 13-14).

grated into a general understanding of path constitution.

2.3 Path dependency vs. path creation?

The central difference between path dependency and creation is the particular understanding of a path's constitution (see Table 1). Arthur and David emphasise the relevance of emergent and non-intended consequences of actions and the stochastic properties of the resulting processes. In contrast, Garud and Karnøe stress the deliberate influencing of technological developments through powerful (collective) actors. The following gives an overview of these properties.

The merit of the path dependency concept is *first*, the refusal of the assumption of technology as always being selected by the market on grounds of efficiency as described in neo-classical economic theory and *second*, the theoretical embedding of technological development in its historical context. This is an important step towards a general socio-economic explanation of technological innovation. As a *further* step, path creation adds to this a more elaborate concept of actors and their role in technological development, as well as an understanding of the broader social dynamics in which the development of a path is embedded. Here, we would like to add to the discussion by first pointing out some as-

pects which deserve further clarification:

1. How can the interplay of evolutionary emergence and strategic deliberate action be adequately described in a general understanding of path processes?
2. How can such a general understanding of path processes be enriched with sociological concepts that go beyond the simplified actor model of classic path dependency reasoning?
3. How can path processes be distinguished from any other forms of stabilisation over time?

In the following, we present a general concept of path constitution which combines the advantages of the path dependency and path creation concepts. Based on this, we attempt to give some preliminary answers to the first question in the remainder of this chapter. We will address the second question in chapters three and four of the paper and, last but not least, deal with question three in our conclusion.

2.4 Path constitution

In order to obtain a more general understanding of path processes in technological innovations, we suggest that the concepts of path dependency and path creation should be combined into one concept of *path constitution* which

Table 1: the basic properties of path dependency and path creation

	Concept of constitution	Path properties
Path dependency	<u>evolutionary-emergent:</u> Paths emerge behind the back of actors, they are not and cannot be controlled by them.	<ul style="list-style-type: none"> - History matters - Increasing returns - Lock-in
Path creation	<u>strategic-deliberate:</u> Paths can be deliberately created by actors, if they are able to mobilise the necessary resources.	<ul style="list-style-type: none"> - History and social actors matter - Increasing returns and mobilising actors - Lock-in

takes into consideration both concepts of path development so that paths can be seen as a mixture of emergent processes and deliberate actions. In our concept we distinguish between two analytic dimensions: modes and phases of path constitution. The modes of path constitution can be used as a sensitising concept for differentiating between the emergent and the deliberate aspects of path constitution, where the phases of path constitution provide us with a simple grid for classifying aspects of emergence and deliberate action within a temporal order. We see the modes and phases of path constitution as analytical distinctions, not as ontological facts, and only use them a) to describe the constituting elements of a path in greater detail and b) to analyse empirical cases more precisely.

Modes of path constitution

The respective conceptualisation of path constitution, both in path dependency and path creation can be seen as the two ends of a continuum. On the one end are emergent completely unplanned processes, and on the opposite end are deliberately and strategically controlled processes (cf. Windeler 2003; Sydow et al. 2004). In the analysis of a concrete empirical case, one has to determine at which point between completely unplanned and completely controlled processes the analysed case is situated. At one extreme of this continuum, the constitution of a technological path is the result of an entirely emergent process, without being planned at all. David's now classic example for this is the emergence of the QWERTY-keyboard.⁴ Close to the other extreme of path constitution we find examples which

are the result of planned processes, like large technological projects initiated by national governments, e.g. the sponsorship of nuclear energy.⁵ More in between the two extremes, we find processes in which the actors do not have full control over the development of the path but are aware of it, and influence it to a certain degree through deliberate actions.

There are different reasons why a path may be only partly controlled. One reason is that the relevant actors do not have the resources necessary to control its development to a higher degree. Or maybe actors just do not want to spend more resources on the control of a path. But in contrast to pure emergent processes, the actors are aware of the development of the path. They observe it, calculate the chances of success in regard to different possibilities, and use their resources to influence the development if they think it is worthwhile. Actors therefore may "bet" on the success of one path. It can also occur that actors bet on more than one of different competing paths, thus "hedging their bets" which especially accounts for large companies with sufficient funds who partake in various competing strategic alliances (cf. Linden et al. 2000). Also path processes may exist, where the direction of the path is the emergent result of deliberate actions of different actors, but the result was not intended by any one of them, e.g. in case of conflicting or competing perspectives.

Phases of path constitution

The development of a path can – analytically – be divided into different phases: generation, continuation and termination. *Generation* describes processes from the beginning of a path until it has stabilised. When a path has become stabilised, the phase of *continuation* begins which may then end

⁴ This is at least true for the description David provides (1985). We assume there is a high probability that also for this case one could at least find some deliberate attempts, e.g. from the company which introduced this specific keyboard design, to stabilise it.

⁵ Of course there are – as the example of nuclear energy clearly shows – limits to such planning.

in a phase of *termination*. This distinction is necessary for integrating path creation and path dependency into our general understanding of path constitution. Also, it is useful for distinguishing different empirical cases.

The *generation* of a new path can have different causes which correspond to different types of processes between the two poles of emergence and deliberate action. For this phase of path generation, it is therefore useful to distinguish between the modes of *path creation* (resulting from deliberate actions) and *path emergence* (resulting from chance and small events). But one thing is crucial: irrespective of how a path has developed, after it has stabilised, and positive feedback has set in, it is very likely to become locked-in. For this, it is irrelevant whether the path emerged as in the case of the QWERTY-keyboard or if it was created by deliberate actions as in the case of the post-it-notes. An example of this is the post-it case itself, where Silver and the other actors managed to establish the post-it note as a product which represented a useful application for their "glue that does not glue". During this process, the path they created became stabilised and now continues more or less on its own.

The phase of *continuation* in case of the post-it notes shows all features of a path as described in the concept of path dependency. First, there are positive feedback loops, which stabilise the path even without any support of the original creators. Today, the development of post-it notes has its own logic detached from the reason why it once was created.⁶ Because the phase of

continuation in both cases – post-it and QWERTY – shows the same features, it seems to be useful to apply the same term for both. We propose to use the term *path persistence* for this mode of a path continuation. This is a deviation from the usual coinage of path dependency, but we think it is nevertheless useful to do so because the concept of path dependency should be a general feature in the description of stabilised paths. Therefore, we disconnect the question of how a path was generated – whether emergent or strategically planned – from the properties of a fully developed path itself. On the other hand, it might be the case that a technological option does not become locked-in by its own virtue but has to be continuously stabilised by deliberate actors. The mode of *path extension* accounts for the mindful contributions that can keep a technological option dominant by organising sustained support from the relevant actors. In contrast to path creation, there is no mindful deviation from existing structures but rather a mindful continuation of an existing path. This requires that actors are aware of the path and have actively decided to support it. However, once the phase of continuation is reached and the process is more or less path dependent, it displays some sort of self-reinforcement.⁷

But this does not mean that a path will continue forever. Even after lock-in is reached, different kinds of further developments are possible. If, for example, a path comes to an end, we speak

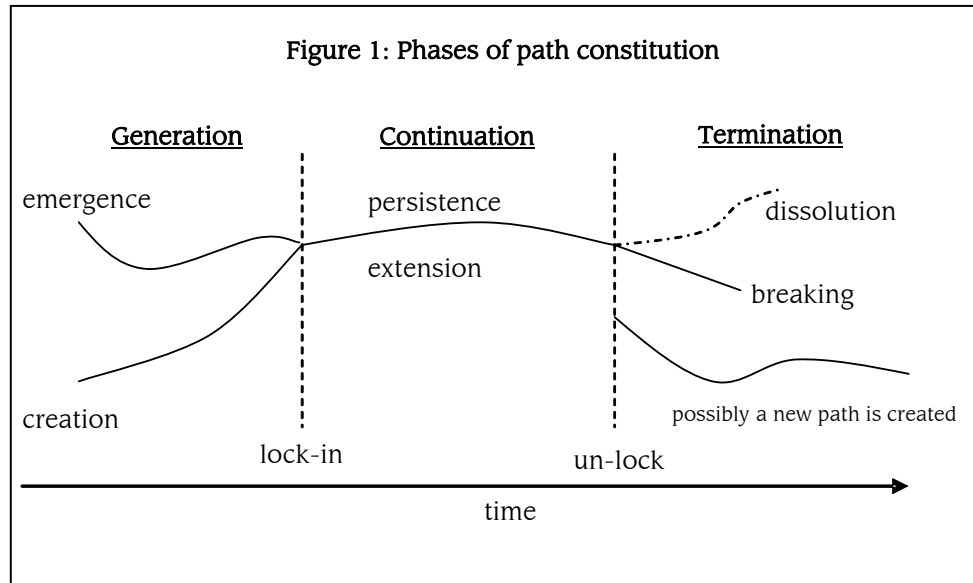
computer programme which allows you to "stick" notes on your computer desktop. So today, the idea even works without a material basis and without glue.

⁶ Two available post-it notes products exemplify this point very clearly. The first are the so called "super-sticky-notes", which have much "stickier" glue than the regular ones. This is a useful product out of a "post-it note logic", but if you consider post-it notes as an application for "glue that does not glue", it is quite absurd. The same applies to "post-it digital notes", a

⁷ Nevertheless, the issue remains that if we look for stabilising effects beyond the mere economic notions of increasing returns, the social and technical processes will not display simple mathematical mechanisms but must be seen as versions of stabilisation much like "technological paradigms" (Dosi 1982) or the "Matthew effect" (Merton 1968).

of *path termination*. If the termination is mindfully created by actors, we would describe this as deliberate *path breaking*. If it results from emergent processes, we call it *path dissolution*.

shaping of innovations (see also Bijker/Law 1992). In order to bridge the gap between the seemingly opposed perspectives on technological innovations either as the product of deliber-



Summing up the discussion above, we come to a tentative definition of a technological path: Technological paths are contingent processes characterised by an increasingly stable interlocking of socio/material elements which eventually lead to a lock-in. The stabilisation of the elements over time is a result of emergent phenomena as well as deliberate actions with respect to a specific technological option. The lock-in may be reversed by chance or by force. We see the advantage of our concept of path constitution in the possibility to integrate different empirical cases into one phase model of path processes, but also to analyse individual path processes with respect to the emerging properties and deliberate contributions of relevant and meaningful actors (see fig. 1).

In the following two chapters we seek to sociologically enrich our proposed analytical framework of path constitution. In particular we elaborate on the aspects of emergent and deliberate stabilisation of individual path processes by taking a closer look at some sociological arguments concerning the role of agency and institutions in the

ate construction or as the result of emergent evolution, we revisit some arguments from path dependency and path creation under the perspective of science and technology studies and neo-institutional theory. This will further our understanding of path constitution from generation to continuation and termination, and lead to a deeper appreciation of the social dynamics at work in the constitution of technological paths.

3 Technological paths and the studies of science and technology

3.1 Studies of scientific knowledge

The studies of scientific knowledge can provide useful insights for studying technological paths, since they have significantly influenced technological development models. Examples are the notion of "technological paradigms" (Dosi 1982) or the concept of the "social construction of technology" (Pinch/Bijker 1987) which we will turn to later. In addition, thoughts from STS have significantly influenced Ga-

rud and Karnøe's notion of path creation, especially with respect to "entrepreneurs as embedded agents" and "momentum" (2001: 9-11). In this part of the paper we will sketch the fruitful contributions of this line of research for a general understanding of technological paths.

In the study of scientific knowledge, the seminal case study of the "genesis and development of a scientific fact" by Ludwig Fleck (1980 [1935]) lends valuable insights into the stabilisation and persistence of cognitive belief systems through deliberate actions. Fleck argued that a closed belief system will often persist in the face of contradictory statements. In this sense, he is often referred to as one of the first constructivist scholars opposing naïve positivist beliefs in natural science (see von Glasersfeld 1989). Fleck is interested in how a scientific belief system becomes stabilised (Fleck uses the term "Beharrungstendenz" – tendency towards persistence – to describe the stability belief systems, 1980 [1935]: 40-53). Here, Fleck specifically analyses how contradictory statements are excluded from the stabilising theory: in the early days of a theory, contradictions may be either unthinkable or may be overlooked. Later, such contradictions are actively kept secret or integrated into the established theory at considerable costs. Lastly, the most active degree of persistence can be seen when scientists resort to rhetoric and fiction rather than facts in order to maintain theoretical integrity. Fleck refers to the broadly accepted interpretations of the world (i.e. scientific theories) as "Denkstil" (i.e. styles of thinking, *ibid.*: 165-190), which shape the individual perceptions of the world. A group of people adhering to a specific style of thinking are called a "Denkkollektiv" (meaning: collective of thought, *ibid.*: 53-70), who actively promote their favoured scientific theory.

The main point of the argument is that this cognitive persistence is mindfully

created by actors with vested interests and – this point being important for path extension – actively defended against contradictory information. If we relate this to technology, Dosi has shown in his study on technological paradigms (1982), that the ideas of rigidity in scientific styles of thinking (Fleck 1980 [1935]), or paradigms (Kuhn 1973 [1962]), can be integrated into an evolutionary concept of technological innovation in the economy (cf. also "technological regime" Nelson/Winter 1982: 258-259). According to Dosi, a technological paradigm shapes the development of technologies because it "embodies strong prescriptions on the *directions* of technical change to pursue and those to neglect" (*ibid.*: 152). These prescriptions include concepts and criteria of technological "progress", e.g. the degree of efficiency or innovativeness. Hence, technology can only be evaluated within a paradigm. The effect of including and pursuing the plausible technical options as well as excluding and neglecting the implausible technical possibilities is based on the assumption that "economic forces' ... together with institutional and social factors, operate as a *selection device*" (*ibid.*: 152). Therefore, in its initial stages, a technology is adopted mainly because the possible alternatives do not seem feasible to the engineers who are, as Dosi puts it, "'blind' with respect to other technological possibilities" (*ibid.*: 153).

Nevertheless, there is a crucial difference between Fleck's social constructivist account of development and Dosi's concept of evolutionary emergence: Dosi sees the socio-techno-economic relations explaining technological developments in terms of a (mainly) *given* selection environment, whereas in Fleck's perspective the selection environment is *constructed and maintained* by the scientists. Especially Fleck's work leads us to an activity centred understanding of stabilising knowledge which can also be applied –

as Dosi demonstrated – to the development of technology. First of all, paradigms or styles of thinking – be they scientific or technological – do not emerge out of the blue, but have a history of deliberate contributions through collectives of actors. Each technological path must thus always be related to its context at any given time.

By looking at the stabilising social, technical, and economic forces in later path developments, the notions of "Denkstil" and "technological paradigm" take us one step further than the idea of mindful deviation in path creation. "Denkstil" draws our attention to the fact that a broadly accepted interpretation of a technology and of technological progress can be actively created and subsequently serves as a central factor in the stabilisation of a path. Dosi's argument about "technological paradigm" stresses the fact that criteria for technological progress are not part of a technology itself, but are part of a technological (cognitive) paradigm which can not only stabilise an existing path but also render alternative solutions unthinkable.

3.2 Social construction of technology

We now take a closer look at STS concepts which help to elaborate on the concept of lock-in and how path processes are actively supported and embedded. David associates three features that lead to lock-in in the case of QWERTY: *technical interrelatedness*, *economies of scale* and *quasi-irreversibility of investments* (1985: 334). However, these features do not stress the role of agency for locking-in a path. In the studies of the social construction of technological systems, the stabilisation and subsequent irreversibility of technological developments is considered to have numerous constitutive elements emphasising the role of agency. In the following we will look at how the notions of technical interrelatedness and quasi-irreversibility (of

investments) can be enriched through STS ideas about agency.

Hughes, for instance, uses the notion of *momentum*⁸ to indicate the role of deliberate agency in the stabilisation of large technological systems: "The large mass of a technological system arises especially from the organisations and people committed by various interests to the system. ... Concepts related to momentum include vested interests, fixed assets, and sunk costs" (1987: 76f.). Hughes adopts the meaning of momentum quite literally from physics as a "mass in motion" which technical systems acquire by having a *mass* (people, organisations, and technology), a *velocity* (growth rate), and a *direction* (commitments and interests). He then elaborates his understanding of momentum with regard to technological developments: "Momentum does not contradict the doctrine of social construction of technology, and it does not support the erroneous belief in technological determinism. The metaphor encompasses both structural and contingent events" (ibid.: 80). Hughes specifically highlights the role of material artefacts for the stabilisation of sociotechnical relations in time: "Durable physical artefacts project into the future the socially constructed characteristics acquired in the past when they were designed" (ibid.: 77). This can be seen as a temporally extended version of David's technical interrelatedness since it connects the "hardware" of material artefacts to the "software" of social processes over time.⁹ In the QWERTY case, the material layout of the keyboard interrelates with the typist's memory of the layout and the technique of touch typing.

⁸ The active generation of momentum is also central in the concept of path creation (Garud/Karnøe 2001: 17-18).

⁹ Of course, one of David's main concerns was to bring time back into the picture of economics in his concept of "historical economics" (David 1993, 2001), however, Hughes points out rightly that the temporal aspects also concern the future.

Hughes brings agency into this process by stressing that the initial characteristics of the material makeup of a technology are socially constructed in the first place and even though technological systems might acquire so much momentum as to appear autonomous, i.e. beyond the control of actors, there is always room for intervention (ibid.: 79).

Because the material qualities of technology are key elements of technical interrelatedness, one has to allow for peculiarities of technologies in order to differentiate between the consequences of, say, keyboard layouts and thermonuclear reactors in the constitution of a path. Especially the stabilising forces of technical interrelatedness (David – in relation to single actors) and technological paradigms (Dosi – referring to collectives of actors) have to be acknowledged as fundamental processes of technological paths.

Let us consider quasi-irreversibility next. In David's understanding, quasi-irreversibilities relate to investments and to the asymmetry of relatively low costs needed to stay on the technological path (e.g. of using QWERTY) compared to relatively high costs of switching (e.g. to the Dvorak Simplified Keyboard, see Parkinson 1972). The afore mentioned "social construction of technology" (SCOT, Pinch/Bijker 1987) approach is primarily concerned with the social shaping of technologies *before* they become standards or quasi-standards. In this perspective, the quasi-irreversibility of technological developments is not only based on investments but also on interests. Bijker introduces the concept of *technological frame* (1995: 122) which is created out of the interaction of relevant social groups with an artefact and which then "structures the interactions among the actors of a relevant social group" (ibid.: 123). Bijker stresses two points which are usually neglected in related concepts like "frames of meaning" (Collins/Pinch 1982) or "paradigms" be they scientific (Kuhn 1973

[1962]) or technological (Dosi 1982): (1) the importance of the interaction with the artefact and (2) the possibility to include all relevant social groups, not just scientists or engineers. Within a technological frame, the relevant social groups – experts and lay persons alike – are engaged in a mutual process of defining what the matter of fact is.¹⁰ For our understanding of the constitution of technological paths, this points to the importance of the strategic and deliberate activities of collectives of actors in creating the frame of reference in which the path is to develop. But at the same time, this highlights the heterogeneity and diversity of the relevant social groups.

The establishment of this frame is, of course, undertaken by highly motivated relevant collectives of actors with conflicting vested interests. In this phase of technological development, the technical interrelatedness must be produced by first making the interaction of the relevant social groups more stable and, in this sense, more irreversible. Bijker shows this vividly in his example of the late 19th century controversy over the shape of the common bicycle (1995: 19-100). The technological path (i.e. the dominant shape of the bicycle) and the technological frame (i.e. the dominant meaning of the bicycle) are co-constructed by the actors at the same time, and to understand path processes more generally, we think it is indispensable to include *frames* as a constitutive element of the path.

¹⁰ In this respect Bijker comes quite close to Goffman's concept of a "primary frame" (Goffman 1980 [1974]: 31-51), when he states that: "A technological frame comprises all elements that influence the interactions within relevant social groups and lead to the attribution of meaning to technical artefacts – and thus constituting technology" (1995: 123). In his concept of "frame analysis" Goffman was mainly concerned with the attribution of meaning in social situation, in which the primary frame provides the basic orientation for the interaction.

Furthermore, the constitution of a technological path has two sides when it comes to the concrete development of technologies by relevant mindful actors. In his classic study of the bicycle, Bijker describes the acceptance of the standard bike as the twofold process of *stabilisation* as an intragroup development (within a group actors supporting one technology) and *closure* as a process located at an intergroup level (i.e. between competing groups of actors, 1995: 84-88). For path constitution we must keep in mind that in order to stabilise a path, the relevant social groups must strive for closure by convincing and committing relevant others to their perspective. Conceptualising stabilisation as a collective process, Bijker argues that "technical change cannot be the result of a momentous act of the heroic inventor" (ibid.: 86). Bijker's understanding broadens the conceptual basis for path creation beyond mere mindful deviation. While mindful deviation might be the first step, the creation of the technological path requires stabilisation and closure on a collective level.¹¹

Bijker, like Hughes, seeks to combine emergent and deliberate aspects into his study of sociotechnical change by referring to closure and stabilisation: "The irreversibility aspect of closure may seem to induce a static element in the description of technical change. This is not necessary, however, because we have the stabilization process to highlight the continuous character of technical change" (ibid.: 87). Once, in Bijker's terms, closure has

been achieved, technological alternatives become relatively undisputed technological standards. These standards have the property of being *taken for granted* and hence become *institutionalised* solutions, two aspects upon which we will elaborate using new institutional theory after a short intermediate summary.

3.3 Intermediate summary

Not surprisingly, the actor model in STS is more complex than the one in path dependency. Actors are not thought of as isolated profit-maximising entities, but as groups of actors embedded in social worlds and endowed with meaning and interests that go beyond mere cost/effect reasoning. From the STS perspective, technological paths do not emerge behind the backs of actors through individual choices but are actively generated by stabilisation and closure through relevant social groups. In this process, the artefacts and human actors are mutually reconfigured until the reciprocal alignment of all entities creates a form of persistence which may exhibit forms of inertia and self stabilisation on technical, social and economic levels, but without ever locking-in completely (compare the notions of "scientific bandwagon" from Fujimura 1988; the "juggernaut" from Giddens 1990: 139; and "techno-economic networks" from Callon 1991).

We think that the notions of technological path and momentum used by Garud and Karnøe are helpful in this respect since the authors point out that: "The steady accumulation of inputs to a technological path generates a momentum that enables and constrains the activities of distributed actors" (2003: 277). If we relate the potential for deliberate activities to the phases of technological development, it seems that the further the technology progresses the possible and plausible activities for the actors become more limited. However, this could enable a new cycle of activities which can

¹¹ This processual perspective is used in Garud and Karnøe's notion of "embedding" (2001; 2003), but for understanding the general constitution of technological paths, we think that the more concrete ideas of stabilisation and closure better serve the purpose of finding conceptual clarity. Whereas stabilisation is specifically needed in the mode of path creation, closure must be achieved for a path to persist and, in addition, it must be constantly maintained for a path to be extended.

be seen as mindful deviations because they differ (radically) from the now taken for granted solutions. Agency can be incorporated in a general understanding of path processes in the way that actors have some sort of leeway which shapes and is being shaped by the activities of the actors: Relevant groups of actors engage in constructing the technological frames by striving for the stabilisation and closure of their preferred option. The more a technological frame is turned into a technological paradigm, the less control the actors have over it. However, a fixed set of rules and norms is the prerequisite for every mindful deviation and deliberate continuation, which is the reason why the progress of a technological path should not be equated with a simple reduction of contingency.

4 Technological paths and institutionalisation

New institutional theory can provide further insights into the socio-economic stabilisation of a technological path. Traditionally focussing on the stabilisation and homogenisation of organisational structures¹² (see Meyer/Rowan 1977; DiMaggio/Powell 1983), in the last few years, the focus of the theoretical debate has shifted towards organisational and institutional change (see Hoffman 1999; Munir 2005). We will argue that as a consequence, especially the more recent and more agency-oriented neo-institutional concepts allow for the analysis of both, the continuation and institutionalisation of technological paths, and the generation of new as well as the change of existing paths. This perspective shifts the focus towards the crucial role organisations play in the process

of technological path development. In the following sections we focus on how concepts from this line of research can be used to describe the development of technological paths and their dependency on institutions, and the institutional structure of the environment in which they develop.

4.1 Path constitution as processes of institutionalisation

Social phenomena such as norms, institutions, professions, organisational behaviour, etc. are central for the understanding of technological paths and their development. Institutional theory is one possible starting point for the development of a more general concept. In the following sections the basic elements necessary for such a concept are outlined.

The notion of *organisational fields* shifts the focus of analysis on the macro level (DiMaggio/Powell 1983; Hoffman 1999). It stresses the importance of the interaction between different groups of organisations forming around a certain product, technology or issue. The properties of such a field of interacting organisations are central for the stabilisation of technological paths as well as for possible change. In addition, *institutional entrepreneurs*, especially collective ones, are a crucial driving force for institutional and technological change (DiMaggio 1988). Different *mechanisms of institutional isomorphic change* (DiMaggio/Powell 1983) lead towards the homogenisation of organisational fields. They are responsible for the stabilisation of organisational forms, and can be a central reason for the lock-in of a certain technology.

4.2 Organisational fields

A fundamental question for analysing technological paths is which level – for example individual actions, the whole world or something in between – is most influential and relevant for their development. Path processes can be described on different levels and often

¹² Even if Meyer and Rowan mentioned that "powerful organizations attempt to build their goals and procedures directly into society as institutional rules" (1977: 49), change and the active role of powerful actors is not their primary concern.

show very different properties on different levels (cf. Bassanini/Dosi 2001). The path dependency concept focuses on individual actors in the market and empirical studies on path creation focus on different levels, varying with the described empirical case. In the case of the post-it note, Garud and Karnøe focus on individual actors within one organisation (2001), in the case of the wind turbine they choose a macro perspective to compare technological development in different countries (2003).

At least for complex technologies, the relevant level of analysis is above the level of individual actors. Considering the resources necessary to develop a new technology and to exploit it, only very powerful actors are able to do so. In our time, these actors are primarily considered to be organisations or even a plurality of organisations. Consequently, to describe these processes, it is useful to focus on the organisational field as the main level of analysis. We argue for this focus as a starting point of analysis because it takes the multiple interactions of collective actors into account. This does not mean, however, that we disregard the importance of other levels like personal interaction or societal dynamics.

An organisational field is constituted by:

"those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products" (DiMaggio/ Powell 1983: 143).

By so defining an organisational field, this concept focuses on a different group of organisations than related concepts like *industries* do. An organisational field not only includes organisations that produce a certain product, but also other organisations whose activities are oriented toward the activities the field is centred around. Hoffman emphasised this property of organisational fields by pointing out that it is not a certain

product which constitutes an organisational field, but rather a specific issue:

"The notion that an organizational field forms around a central issue [...] rather than a central technology or market introduces the idea that fields become centers for debates in which competing interests negotiate over issue interpretation. As a result, competing institutions may lie within individual populations (or classes of constituencies) that inhabit a field, becoming situated institutions" (Hoffman 1999: 351).

Of course a specific technology or some features of it can be an issue around which a field forms, but the field is not reduced to the organisations actively involved in the production of this technology, it includes all organisations that focus their activities on this specific technology. Because of this, it allows more aspects of both to be taken into consideration, change and stability, than other related concepts would allow:

"the interorganizational field context is the appropriate level of analysis for understanding the interplay between a field's structural evolution and change in its institutional practices. By incorporating network, cultural, and historical elements, interorganizational fields provide a fruitful context for tracing and interpreting the nature and process of change in institutional practises." (Scott 1992: 333).

Organisational fields show some of the features which are central for the analysis of technological paths. They are dynamic, change over time and their structure depends on the history of the field, and cultural elements of its environment. An organisational field is more than a mere accumulation of organisations which show interest in a specific issue. Organisations within a field form groups which are – in relation to the issue of the field – homogenous within and heterogeneous among each other. In some highly structured fields, organisations belonging to one group create *meta-organisations* (Ahrne/Brunsson 2005), e.g. associations which are supposed to represent their interest within the field and allow them to speak with one

voice. Because different groups of actors have different interests in the field's focal issue, contradicting values and norms supported by different groups of organisation can exist within one field. In this case, different groups of organisations try to stabilise their perspectives, values, and norms throughout the whole field while trying to suppress alternative perspectives from other groups of organisations. This corresponds well with the concept of "relevant social groups" which struggle for the definition of a certain technology as it is used in SCOT (Bijker 1995: 45-50, 93-96). If norms and values are stabilised throughout the whole organisational field, this can provide it with an enormous amount of stability and inertia. In addition, changes in the members of the field can increase or decrease its stability.

In addition to the involved *actor constellation*, the central elements of an organisational field are the *technologies* used in it, the *regulations* relevant for the actors, and the *practices* of the actors within the field (Leblebici et al. 1991). The field's structure and dynamic are a result of the interaction of these four elements. If and how a technological path can develop depends on the structure and dynamic of an organisational field which is formed around the potential path. A certain degree of homogenisation of an organisational field is a prerequisite for path continuation. The more stabilised an organisational field is, the more it determines the way in which technology is developed within it, and the more it supports ideas generally taken for granted about technological progress shared within the field and forming the core of technological paradigms. However, the more concepts of technological progress differ within an organisational field, the more a developing path needs to be actively supported and extended. If this does not occur, there is a high probability it will be terminated or dissolve.

4.3 Institutional Entrepreneurship

It is important not to describe organisations as just passively adapting to environmental requirements. As powerful actors, organisations try to influence their environment and its development and seek to change or even create the institutional setting they require in ways which support their goals. Consistent with this perspective is the concept of *institutional entrepreneurs* (DiMaggio 1988), who actively influence institutions and institutionalisation. A good example of institutional entrepreneurship is the active creation of a technological path as described by Garud/Karnøe in the case of the post-it note. Silver succeeded in mobilising very different kinds of resources in order to stabilise the development he had started by mindfully deviating from existing rules and norms. That is exactly what institutional entrepreneurship is about. But institutional entrepreneurs are not isolated actors. While trying to influence their social environment, institutional entrepreneurs are nevertheless embedded in it. They are, for example, integrated in relevant social groups. In general, actors are influenced by their social environment. It influences their norms and values, they have to react to it, and have to take it into consideration when trying to change parts of the institutional setting (Garud et al. 2002).

Users of a technology need to be able to judge competing designs and to do so, they require accepted standards by which they can compare one technology with another. Imagine a situation in which every company sells individual systems no-one else offers. This would lead to a severe confusion of potential customers. To make a comparison possible, even competing companies may cooperate with each other in order to agree on common standards and criteria of progress as is the case in the current debate over the Blue-Ray Disc vs. HD-DVD. By developing a technology, the relevant actors at the same time mindfully construct

the technological, social and economic settings in which the path is to be generated and later continued. Institutional entrepreneurs at work in path creation are then concerned with setting up a technological frame within the appropriate technological paradigm, mobilising the relevant social groups, and influencing regulations. In short, they are generating momentum on many different levels. Even when the path has become more or less locked-in they will still have to manoeuvre skilfully within the organisational field so as to maintain and sustain the technological path, defend it against opposition, and handle the technical, social and economic fluctuations in the field.

Therefore, within an organisational field, powerful actors – single organisations or groups of organisations – influence their own institutional environment in the interaction with other groups of organisations. *Institutional entrepreneurship* within an *organisational field* constitutes the central element of institutional change.

4.4 Institutional isomorphic change

Other institutional concepts put a stronger emphasis on the stabilising effects institutions and processes of institutionalisation have. Maybe the most prominent concepts are the *mechanisms of institutional isomorphic change* (DiMaggio/Powell 1983: 67). They are described as the primary reason for homogeneous organisational structures within an organisational field. The three mechanisms are (1) coercive isomorphism, actors (especially political ones) influence or force organisations to adopt certain structural elements, (2) mimetic isomorphism, organisations copy structures of other organisations, and (3) normative isomorphism, resulting especially from professionalisation. These processes do not only apply to organisational forms in general but also to concepts of technological progress and how, for example, R&D is done within

organisations and throughout an organisational field. Many of the mechanisms described in the path concepts and in the extensions through STS can be combined with these mechanisms. An example of potential consequences of coercive isomorphistic pressure is the description of the different roles of engineers in both cases of the wind turbine development in the USA and Denmark (Garud/Karnøe 2003). Isomorphistic pressure in general has the tendency to support and strengthen already prevalent institutions. Also, together with technological artefacts, it stabilises already established technologies and those which are assumed or expected to be successful.

In addition institutions within an organisational field can stabilise on a cognitive, normative and/or regulative dimension (Scott 1995b). Institutions which are stabilised on the regulative dimension are consciously set and legally enforced, cognitively stabilised ones are unconscious and taken for granted (Scott 1995a: 51). The normative dimension lies between the two extremes. In a final step, we will use these three dimensions to clarify our discussion of path constitution and science and technology studies with respect to institutional theory.

First, the *cognitive* dimension is relevant for all three approaches. In classic path dependency, for instance, it is the typist's memory which is irreversibly interrelated with the keyboard layout, and in path creation, the mindful deviation from existing procedures is stressed. Especially for the studies of scientific knowledge, the cognitive dimension plays a major role. Here the notion of paradigm corresponds well with the taken for grantedness of social institutions. However, as Fleck has pointed out, such taken for granted styles of thinking may have been actively created beforehand. For analysing path constitution we would thus have to consider the stabilising forces of taken for granted institutions or paradigms as well as influences from

mindful deviation and strategic creation of novel or perhaps just different cognitive compositions. Empirically we could then trace distinct changes in paradigms (i.e. the implementation of components previously considered utterly impossible) and analyse their role for the constitution of the technological path.

Second, on the *normative* dimension, classic path dependency reasoning has little to offer as an explanation. In path creation, mindful deviation is the deliberate aberrance from existing norms. STS always acknowledges the mutual construction of technology and social norms, especially in the form of practices. However, there is rarely any conceptual room for a normative dimension. If we think of technological paths as innovations that are largely being conducted by multiple collectives of actors, this dimension probably deserves more attention since it can be used to bridge the gap between the conscious use of legal regulations and the taken for granted paradigms. By analysing the negotiations and controversies within an organisational field, we can trace the influence of established norms for the constitution of the path while, at the same time, we remain aware of how the norms themselves might be changed in the process.

Third, the *regulative* dimension is important if we consider technological innovations to be developed by organisations within a larger regulative framework, especially if the shape of the technologies themselves is subject to laws and regulations. David (2001: 26) referred to such external shocks as one plausible reason to break a locked-in path. When looking at innovations before they become locked-in, the regulative dimension is not only important for the shape of the technology itself, but also for the specific ways of coordinated research and development between different organisations. Here we can frame the innovative manoeuvrings as forms of institu-

tional entrepreneurship, where powerful actors seek to influence the regulative dimension in order to create a suitable context for the technological path. This has also been an issue in the STS cases on large technological systems, but again we argue for a higher analytical status. When analysing the constitution of a technological path, changes in written regulations like laws can be scrutinised in order to understand the degree in which the relevant social groups are able to consciously influence regulative frameworks in their favour and in how far this influence can be used to further stabilise the path or, as the case may be, unintended consequences arise out of those purposeful actions which again need to be dealt with.

5 Conclusion

We have argued for a conceptualisation of technological paths which takes into account deliberate actions as well as emergent evolution in path processes. Technological paths are not mere historical coincidences as classic path dependency would argue, but are influenced by mindful actors without being under their complete control. The first of our two analytical dimensions – the mode of path constitution – helps to bridge the gap between the classic evolutionary concept of path dependency and the actor-oriented notion of path creation (a similar approach has been made with respect to evolutionary economics and the concept of niches by Schot/Geels, forthcoming). The second dimension – the phases of path generation, continuation and termination – helps to sort the empirical cases with respect to the contexts the technological path is embedded in, since research and development are usually conducted under different premises than market transactions. By choosing the idea of lock-in (and then un-lock) to separate the individual phases, we highlight the different phases of path constitution as

an analytical distinction. However, this is only aimed at providing a rough grid for mapping a gradual perspective of deliberate and emergent aspects in the constitution of technological paths.

By adding these perspectives we lose some of the elegance of the original concept of path dependency. However, we think this is necessary to extend the idea of path processes beyond the initial area of application, and to overcome the simplifications from predominantly "blind" evolutionary selection processes behind the backs of actors. Drawing on the literature from science and technology studies and institutional theory, especially with respect to the role of agency and institutions in the shaping of technological innovation, we hope to further our understanding of the general constitution of path processes. The agency of collectives of mindful actors is of major significance for explaining the social shaping of technological innovations. Likewise, institutional theory brings forward the notion of the institutional entrepreneur who influences the change of social institutions thus bringing the mutual shaping of technology and institutions into focus: The analysis of a technological path, on the one hand, consists of tracing the innovative activities concerning the technological development and, on the other hand, relates them to the simultaneous fabrication of cognitive, legal, and normative dimensions of institutions. However, innovations and institutions are not like soft putty in the hands of technological or institutional entrepreneurs. Social institutions, styles of thinking, and technological paradigms make some technological developments more plausible and therefore more probable than others, they lay out conceivable trajectories and are themselves stabilised when a technology progresses along this trajectory.

Furthermore we would like to point out three insights from our discussion of science and technology studies as well as institutional theory. *First*, Bi-

jker's analytic distinction between stabilisation on an intragroup level and closure on an intergroup level nicely points out that we are dealing with innovation as a multi-level phenomenon. Particularly on the intergroup level of closure, institutional concepts like the organisational field provide a useful perspective for analysing the constitution of a path through heterogeneous constellations of actors with diverse interests. *Second*, especially Fleck's study on the generation of a thinking style and thinking collective provides a fruitful case of how institutional entrepreneurs strategically develop a technology while at the same time creating the institutional frame for it. In this respect, the concepts of technological frames and paradigms also help to highlight the importance of non-technical aspects for the development of technologies. *Third*, the level of analysis of each empirical case needs to be specified. We have argued for organisational fields as a good starting point but, in general, a multi-level approach helps to distinguish between the unit of analysis, i.e. the technological path and its constitutive elements, i.e. the respective actions and embedding social institutions. Even the notion of an emergent suboptimal lock-in in classic path dependency reasoning can not be understood without reference to the actions of the individuals or the established market practices. Therefore, paths never exist in a vacuum but only in the rich habitat of social actions and institutions. In addition, when we look at more complex technologies today, we observe numerous technological fields interrelated in mutual stabilising processes, e.g. when we consider the interrelation of the automobile industry with the petrochemical industry, where the expertise of the engineers constructing petrol powered engines nicely interlocks with the economic interests of large oil companies.

So, what is it that distinguishes a technological path from any other

form of temporal stabilising process? In sum, we consider technological paths to be contingent development processes that extend over longer periods of time and in which specific social and material interrelations occur. On the one hand, these socio/material arrangements may emerge, persist, and dissolve while on the other hand they might be created, extended, and broken. Therefore, technological paths are *first* – and unlike path dependency or path creation – not characterised through one specific pattern of development but are constituted through the mutual configurations of social and material elements. *Second*, technological paths will display distinct patterns of development over time which can be analysed with respect to the degrees of emergent evolution and deliberate creation. It would be futile to describe the development of a technological path without emphasising the role of self-reinforcing or at least self-stabilising features.

Our understanding of path constitution allows us to look beyond mere economic increasing-returns and to integrate cognitive and institutional aspects of self-reinforcing dynamics into the picture. The ensuing stabilisation of a technological option can take the form of establishing one dominant design among competing options or the successive re-configuration of one option until it becomes a sort of standard. Eventually, this development pattern will culminate in a form of lock-in, i.e. a stable, quite irreversible arrangement of material and social components. How this irreversibility is constituted in specific empirical cases is one of the most fruitful questions to be answered in the study of technological paths.

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Producing difference in an age of biosociality. Biohistorical narratives, standardisation and resistance as translations

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Abstract

This paper brings together thinking from the history of science, science and technology studies and social/cultural anthropology to better understand how human diversity is handled in everyday practices in science and beyond. Our aim is to take the social and historical contingency of practice as a starting point and to focus on the patterning of practice, which arises from the constraints of socio-material alignments and leads to the co-production of diversity.

Under the headings of race and ethnicity, sorting practices with regards to human diversity have been at the centre of anthropological thinking and critique since the age of Enlightenment. Constructivist critique has insisted on understanding "race" as a social construct and warned of reifying differences of a socio-cultural making. This critique has so far not been particularly fruitful in dealing with human biological difference as produced in different everyday practices in science and beyond.

Recently, molecular genetics have reinvigorated the interest to stratify human populations into subpopulations to improve drug development and targeting, to ascertain vulnerabilities and plasticity, to adjust nutritional intake or therapeutic strategies or to trace ethnic ancestries. We suggest that the shortcomings of constructivist critique in the face of these latest developments are due to its focus on theoretical concepts and self-descriptions rather than the practices and their implicit logics within and outside science proper. By employing Hacking's concepts of 'making up people' and 'looping', Rabinow's 'biosociality', as well as Callon's concept of 'translation', we hope to show the interactive dynamics of classification and response which take place at the interface between different knowledge practices. We trace translations through the life sciences into clinical practice and beyond into different social constellations, involving medical practice, made-up people and social bodies in order to show how human diversity is produced in practice. We put an emphasis on the different roles that biohistorical narratives, standardised packages and forms of resistance and appropriation play within these constellations.

1 Introduction

1.1 Making a difference

Practices of sorting and classification are an all-pervasive feature of everyday life not only in modern societies (Star/Bowker 2000). These practices create difference. In many cases, they are procedures structuring daily activities such as separating administrative papers from academic papers on our desks or distinguishing between options for lunch. Already at this seemingly trivial level, "sorting things out" as a knowledge practice requires different actors, strategies and artefacts to relate to each other in order to make sense of particular constellations.

Where society or social order is concerned, the effects of sorting practices have always been at the centre of social scientific investigation without the practices themselves necessarily receiving a great deal of attention. It is perhaps Luhmann's thinking on the nature and role of observation as *necessarily* distinguishing between two kinds, which has been most centrally concerned with sorting practices themselves rather than just their effects (Luhmann 1992).

The need to distinguish between kinds gains a particular relevance when it comes to biological differences between human beings. While state-of-the-art biological knowledge portrays the human species as existing along a spectrum of continuous variation within which reasonable categories cannot be justified¹, everyday practice in the sciences as elsewhere necessarily makes distinctions also on the basis of biological markers. How this discrepancy is handled, rather than its ontological status, is the focus of this paper. Classificatory practices are thus

understood as necessarily intertwining scientific-technical knowledges with political-moral discourses.

Under the headings of race and ethnicity, sorting practices with regards to human populations and diversity have been at the centre of anthropological thinking and critique since the age of Enlightenment. As scientific practices, they gained more importance in the late 19th century, at the peak of colonialism, and with the rise of empiricism in administration as well as the sciences (Hacking 1990). Throughout the 20th century, notions of human diversity have undergone fundamental changes, not only as responding to the terrible consequences of racist thinking, but also due to alterations of political as well as epistemic cultures.

Although cultural anthropologists and social scientists particularly in North America had begun to critique biological notions of race and ethnicity since the beginning of the 20th century, this critique became influential in political and scientific contexts in the second half of the 20th century. After World War II, with active participation of geneticists and anthropologists in anti-racist campaigns, a seemingly stable public consensus was reached about the biological insignificance and meaninglessness of racial differences (Reardon 2004). The idea that race is a social construct and thus an object of social rather than biological inquiry has been gradually developed towards a constructivist critique ever since.

The scientific "puzzle" of human diversity, however, has not disappeared. Physical anthropologists around the world did not abandon concepts of race but carried on employing racial categories in working routines and academic textbooks. Towards the end of the 20th century, population genetics shifted notions of human diversity from race to population. Public proclamations of the biological meaninglessness of race accompanied the en-

¹ See, for example, the publications of the Max-Planck-Institute for Evolutionary Anthropology (Grine et al. 2007) or the American Anthropological Association (AAA 1998).

deavours to decipher the human genome in the late 1990s.²

Yet only a few years later, the problem of "found"³ biological difference re-emerged and with it the question how to interpret and attach meaning to it as well as its usefulness in biomedical research and therapy (Reardon 2004). The Human Genome Project and the subsequent "-omics" initiatives to decipher different levels of complexity all the way to the epigenome (Murrell et al. 2005) have reinvigorated the interest of the life sciences to stratify human populations into subpopulations for a whole range of reasons: to improve drug development and targeting (Anderson et al. 2003, Evans/McLeod 2003, Evans/Relling 1999, Watters/McLeod 2003), to ascertain vulnerabilities and plasticity (Hsu et al. 1996), to adjust nutritional intake (Afman/Muller 2006) or therapeutic strategies (Lin et al. 2006, Pi/Simpson 2005) or to trace the ethnic ancestry of individuals. While the vision of personalised medicine still faces fundamental obstacles on its way to market fruition (Kollek et al. 2003, Lee 2003), biomedical sorting of human populations finds broad support in research and industry and is common practice today.

This calls for attention on part of the humanities and social sciences. Yet particularly in Germany, the response has been virtually non-existent. While scholars in the humanities approach human diversity studies – and that means, mainly publications of biologists – from the perspective of discourse analysis, social science investigations of current biological or medi-

cal *practice* and its effects *outside* science proper with respect to human diversity are rare. Internationally, particularly in North America, the response has been different if not necessarily all that more fruitful. In the US and in Canada, anthropology⁴ enjoys a much more prominent position within the scientific debate and has insisted on understanding "race" as a social construct, warned of reifying differences of a socio-cultural making and continuously critiqued any sign of re-naturalisation and essentialising (Cooper et al. 2003, Duster 2006, Epstein 2004, Goodman 1995, Holden 2003). Nevertheless, beliefs in race as a biologically clearly identifiable difference remain prominent not only in parts of the scientific community but also in public and media discourse. Further, in politics and administration, race as a non-biological concept is still used in prominent processes such as the US Census.⁵ It is thus by no means clear what effect the constructivist critique of cultural anthropologists is producing. The American Anthropological Association (AAA), however, is set on continuing their line of critique and has now begun to think preventively by starting to produce educational packages designed to deliver the constructivist message to schools.⁶

² The "population paradigm" seems to allow for a much more differentiated, and hence more sophisticated, representation of human diversity, but it differs significantly from the constructivist idea that human diversity is nothing but a social construct.

³ "Found", as a play of words, is here meant to point to the problematic relationship between data and knowledge as well as representation and fabrication of scientific facts.

⁴ Translations between German and English often lead to terminological confusion: In Anglo-American contexts, "anthropology" means "cultural anthropology", if no attribute is added (such as "physical anthropology", which is a discipline in its own right). Especially in Germany, "anthropology" stands for "physical anthropology", if no further attribute – such as "historical" or "social" – is added. Furthermore, the terms "race" and "Rasse" are no equivalents either. While "Rasse" stands for biological aspects of diversity only, "race" represents more than biological notions, however it might be reduced to its biological meaning in certain situations.

⁵ See www.census.gov

⁶ For further information see the American Anthropology Association website, with links to various scientific statements, edu-

The response of the bioscience community to this critique needs to be examined carefully. Since the debates around the Human Genome Diversity Project, public and scientific resistance to research that operates with race as an implicitly biological concept is being taken seriously. A number of editorials appeared in prominent places to clarify that race has no biological basis, that intra-group variation by far exceeds inter-group variation in all meaningful studies, that it is a social construct (Holden 2003, Kittles/Weiss 2003, Lee 2003, Whaley 2003). Yet, while accepting race as a social construct, biological differences within human populations nevertheless remain important.⁷ Many recent controversies have illustrated that the decision whether these biological differences are accepted as a viable means of differentiation depends on a whole host of factors in- and outside of science proper, only some of which are being problematised to a certain extent within the biomedical community itself.⁸ In the spectacular cases, such as the US FDA approval of the heart failure drug BiDil for African-Americans (Kahn 2006) or the stalling of the Human Genome Diversity Project (Cavalli-Sforza 2005), the reasons lay in regulatory policy, economics, political and moral resistance as much as in the science itself (M'Charek 2005).

In the laboratories, however, away from the relative glare of public social and ethical scrutiny, race continues to be used for rather pragmatic reasons of data availability, comparability and

marketing chances. This difference between politically correct, purified self-description and everyday practice is significant. Althusser and Bachelard have pointed out the need to distinguish between the natural scientists' spontaneous philosophy and the operative epistemologies of scientific practices (Althusser 1990). Yet current social constructivist critique struggles to deal with this differentiation because it attaches to the theoretical concepts and self-descriptions rather than the practices and their implicit logics.

Further, we suggest that social science research has systematically failed to take into account materiality. From the turn of the last century, scholars such as Durkheim, Weber and Simmel and, later, Kuhn, Adorno and Habermas have insisted on a domain of the social resolutely purified from materialist encroachment; all, of course, for very good reasons of resistance against an increasing "confused positivism" (Whitehead 1968: 179 German version, transl. by authors). In Germany, a new sociology of technology, which emerged in the 1980s, (re)introduced materiality by analysing its complex integration and multiple role within networks of agency (focusing particularly but not only on technological artefacts) (Joerges 1987, 1988). In a similar vein, studies on the social construction of technology emerged around the same time, portraying materiality as enacted or at least conditioned by social practice (Bijker et al. 1987). This paved the way for an historically informed science and technology studies and actor-network-theory, which further differentiated the role of materiality as technology in social analyses of scientific practice (Biagioli 1999, Knorr-Cetina 1999, Latour/Woolgar 1986, Pickering 1995). Yet materiality as body, as physiology and as biology has remained largely outside of social scientific analyses, with very few exceptions in performative approaches which focus on em-

cation projects and material: www.aaanet.org and <http://raceproject.aaanet.org>.

⁷ This is not to say that the changes, which have occurred have been merely rhetorical; though a perceptible increase of the use of a biologically based notion of ethnicity in scientific publications has occurred (Kaplan & Bennett 2003; Zhu et al 2005).

⁸ See the 2004 supplement of the journal *Nature Genetics*, titled "Genetics for the Human Race", that discusses the problematic aspects of this phenomenon 2004 (2004).

bodiment as body enacted through technological practice, but do not cross the border to integrate physiology (Akrich/Pasveer 2004, Berg/Akrich 2004, Epstein 2004, Gomart 2004, Latour 2004, Lock 2004, 2005, Mol/Law 2004, Van Der Ploeg 2004). Still firmly entrenched in a constructivist dialectic, much of cultural anthropology is not even prepared to talk about biological difference for fear of being accused of reifying social difference.

1.2 Beyond constructivism

How to move beyond constructivist critique has thus become a prominent challenge in the social sciences. The annual meeting of German sociology 2006 seemed to offer a somewhat realist position, which begins to take materiality as revealed by the biosciences as fact. As a consequence, sociology – at least according to the emerging consensus of its practitioners – ought to focus on the non-material aspects left to socio-cultural shaping. We take this position to be too defensive.

Taking up some of the strands from the more courageous debate in the 2006 STI special issue (Schulz-Schaeffer et al. 2006), we use the example of human biological difference to demonstrate a different way of handling the modern dichotomy between nature and culture by bringing together thinking from the history of science, science and technology studies and social/cultural anthropology.

This paper, then, is meant to demonstrate the need for a heightened sensitivity towards certain theoretical strands when working in and on knowledge practices concerned *inter alia* with different forms of materiality. While it leans to a degree on concepts from a social anthropology of knowledge, actor-network-theory and a historically sensitised science and technology studies (STS) as well as philosophy of science, its primary goal is not the positioning in one or another theoretical framework. Rather, we understand theory in the sense of

Deleuze and Foucault as a tool, which is necessary to understand the logics of modern constellations (Deleuze 1997).

Our "field", human diversity in everyday scientific practice, at a first glance seems to be primarily one of scientific actors, hence suggests an investigation using an STS vocabulary. Yet what we are hoping to show is the multiple embeddedness of scientific practice in social and political contexts. While concepts such as epistemic culture (Knorr-Cetina 1999) have been developed from work on scientific contexts, the multiple interactions, resistances and co-productions between scientific practices and social contexts have received less attention outside a rather narrow social psychological or public understanding of science perspective (Stifterverband 2000) and its critique (Irwin 1999, Irwin 2001, Wynne 1996, 1999). In spite of many more or less successful attempts to abandon the division line between science and the public (Goschler 2000), historians of science have rarely traced the easy travelling of knowledge practices between those spheres (Hess 2000). Similarly, social science work rarely focuses explicitly on the multiple interactions between scientific practice and a wider social context.⁹

We thus take as our starting point Ian Hacking in order to focus on the interfaces between scientific and everyday practice:

"I coined two slogans. The first one, 'Making up people' referred to the ways in which a new scientific classification may bring into being a new kind of person, conceived of and experienced as a way to be a person. The second, the 'looping effect', referred to the way in which a classifi-

⁹ A notable exception in sociology is certainly Ted Benton's 1991 programmatic paper on biology and social science (Benton 1991), while Peter Baldwin's "Contagion and the State in Europe" opens up another line of thinking on the link between scientific expertise and political ideology (Baldwin 1999).

cation may interact with the people classified." (Hacking 2006: 1)

The interactive dynamics of classification and response take place at the interface between different knowledge practices, hence they demand not only a different theoretical repertoire but also a wider approach to empirical work. While this paper does not focus on the inherently political nature of classificatory practices, it is important to note that *making up people* and *looping*, particularly in contexts of illness/disease, are intimately tied to transformations and thus technologies of the self, which are themselves – as patterns of practice – part of wider biopolitical assemblages in motion (Rabinow/Rose 2006, Rose 1998, 2001)¹⁰.

As a philosopher and historian of science, the material on which Hacking draws has a tendency to lead to a rather linear thinking of classification processes. Though his "engines of discovery" escape the narrow focus of a history of ideas, they nevertheless lack the attention to knowledge practices in the public domain and outside of science proper. Callon's concept of translation appears to be more useful in this context (Callon 1999). We take translation to refer to a dynamic knowledge practice aimed at creating an alliance or network, which in this shape or form did not exist before. Translation emphasises the transient nature of alliances, the spatial-temporal patterning of interactions as well as the ambivalent dynamics of such constellations of *actants*. Translation allows for symmetry of material and human agency¹¹ and operates via *interesse-*

ment to position and engage actants. Central to these mechanisms is the notion of something fact-like, which is able to travel across contexts. This fact-like entity has been referred to as standardised package (Fujimura 1992), *faitiche* (Latour 2002) or boundary object (Star/Griesemer 1989) with different connotations.

The following section will trace translations through the bio- and life sciences into clinical practice and beyond into different social constellations in order to show how human diversity is produced in practice.¹² Giving the breadth of the topic and the focus on the epistemology of social scientific investigation, this paper is necessarily only able to produce a cursory impression, which must neglect details many readers will perceive as important.

2 Practicing Diversity

2.1 Biohistorical narratives

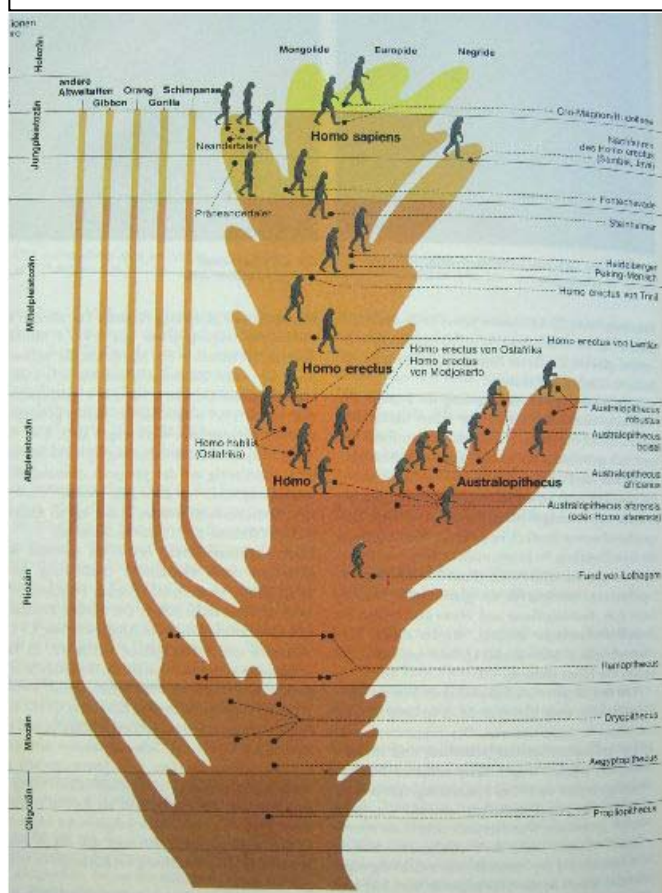
The following sections use observations on the production of knowledge surrounding human diversity to illustrate how classificatory practices produce difference. To avoid an overly complicated picture, we focus on the knowledge production in regard to one specific "branch" of the *homo sapiens* pedigree, namely, the Europeans. This branch, however vague its extensions were imagined, was termed "the European race" in the beginning of the 20th century, "Caucasian" or "White" in anglo-American contexts and "Europids"

standing of agency as we know it from social science.

¹⁰ We thank the reviewers for emphasising the intimate link between Hacking's argument and the line of work on governmentality and related concepts. While we will certainly take this into account throughout the course of the forthcoming work, we apologise for having to leave the political nature of classification rather more sketchy than it deserves in this context.

¹¹ The concept of material agency (see below) does not imply an analogue under-

¹² Much of the methods and the empirical material discussed here comes from three interdisciplinary research projects all coordinated at Humboldt University, Berlin: C:SL Collaboratory – "Social and Cultural Anthropology of the Life Sciences" (www.csal.de); collaboratory project "Imagined Europeans. The scientific construction of the *Homo Europaeus*" (www.imagined-europeans.org); research cluster "Preventive Self: an interdisciplinary investigation of an emergent form of life", www.csal.de)

Figure 1: Pedigree of *Homo Sapiens*

source: Linder/Bayrhuber 1991: 428

– in contrast to "Mongolids" and "Negrids" – in Europe, particularly in both Germanies, up to the 1990s.

The first scientific attempt to classify different human kinds was undertaken by Carl Linné, who separated the *homo sapiens europaeus* from three other 'races' already in the 18th century. Shortly after, Johann F. Blumenbach coined the term Caucasian for white people who according to his thinking were the ancestors of the human species and had emerged from the Caucasus (Baum 2006, Jacobson 1998).

In the late 19th century, the classification of human beings increasingly required much more than mere theoretical speculation. It became, first of all, an empirical enterprise. Skulls and bones were excavated and measured; bodies of living humans were scrutinized and the results carefully reported in complex inscription regimes. As

soon as serological methods were available for large-scale investigations, blood samples were taken and analyzed in laboratories in order to find racial differences. Anatomists searched for racial diversifications of brains and skeletons. Methods and findings of such research endeavours in the materiality of human diversity might not seem very convincing to today's reader, but they enjoyed the prestige of objective and empirically proven scientific practices at the time.

The European was not the primary object of anthropological interest.

Anthropologists throughout the 19th and the greatest part of the 20th century simply took for granted that Europeans existed as a clearly demarcated biological group. Rather than making the *homo europaeus* an object of their research, anthropologists used him as a point of reference and control in the investigations of non-Europeans. Especially during research endeavours to the colonies, anthropologists and medical practitioners were engaged in distinguishing and comparing human groups according to their physical constitution. The primary sorting mechanism relied on the difference between European and non-European.¹³

In contrast, investigations within Europe focussed on sub groups of the Europeans, such as "national" or "regional races". During the first half of the 20th century, attention shifted towards subdivisions of Europeans themselves. Not contradicting this focus on subdivision, it often went without saying that the sub group under scrutiny was at the same time considered European. Against the backdrop

¹³ This is obvious from the research design of studies such as Bruck 1907, Fischer 1913.

of a common European ancestry, anthropologists also began to focus on distinctions between Northern, Eastern and Southern Europeans, between and even beyond nation states.

More detailed differentiations hence did not contradict or break up the classification of mankind into several major races, such as Europids, Mongolids and Negrids. From the early beginnings of human diversity studies all classificatory schemata were based on three or five races. Although, for example, the vision of an "Aryan race" began to dominate the first half of the 20th century in Germany, simultaneously the classification into three groups introduced by anthropologist Egon Freiherr von Eickstedt in the early 1930s was retained as reliable scientific knowledge (Eickstedt 1934). After World War II, in both German states, as in the UK, the USA and the former Soviet Union, and in spite of anti-racist activities, a classification of humans into three or five races gained wide acceptance and was retained in encyclopaedias as well as teaching materials until the 1990s (Reardon 2004, Feustel 1990, Knußmann 1996, Nesturch 1959, Straaß 1978).

Since the 1980s, population geneticists have continued to point out that the genetic diversity of the human species does not permit such coarse classifications. Rather, the species can only be separated into manifold subgroups – populations – separated by continuous transitions instead of sharp breaks. Molecular genetics seems to have issued the final word on the race question. The "population paradigm", as one might term it, has allowed for impressive public and political proclamations about the biological meaninglessness of race.¹⁴

Yet at the same time, racial classifications remain central to biomedical research as well as clinical practice.

Race has been (re)invented as a meaningful category in medical genetics research in the last ten years or so. And while human geneticists proclaim that the inter-individual variance of human genomes is not significant, the work in human genetics laboratories concentrates on genetic differences between populations – be it European, Japanese, Danish, or Afro-American. This discrepancy not only demonstrates Althusser and Bachelard's argument, it also marks the gap which makes constructivist critique difficult.

In order to explain this discrepancy, it is important to take a closer look at the historical presumptions as well as current narratives inscribed into DNA sequences from the perspective of evolutionary biology. Each DNA sequence with its particular piece of genetic information is wrapped within a certain biological story: several variants exist of each sequence. To explain how this variety has come about, biologists tell evolution stories which require only a few concepts such as mutation, selection and drift. In laboratories, these stories are continuously produced and reproduced, diversified and finally told as the stories of larger groups or races. We term these biological stories told by bioscientists "biohistorical narratives".

Plants and animals do not pay much attention to the stories biologists tell about their ancestry, and they do not leave behind historical records and documents. In the case of human diversity, however, these stories describe historical events using biological terms and might therefore generate conflicting narratives on human history.

Biohistorical narratives are not confined to the domain of science – quite the contrary: They constitute integral elements of the identity building of many nations, families, ethnic groups or other social entities. However, since genetics and evolutionary biology have become the predominant source of knowledge on diversity and heredity,

¹⁴ See for example the UNESCO statements on race (Reardon 2004).

most of those rather mystic narratives need to be aligned with modern genetics in order to be consistent with contemporary understanding of "how life works". To explain, for example, why children resemble their parents, families draw on their understanding of modern genetics. To explain how the early ancestors of modern Europeans became European, geneticists tell stories about historical events that shaped what today we know as ethnic diversity or human populations.

The concept of biohistorical narratives is meant here to illustrate on the one hand how cultural-historical presumptions enter lab science. On the other hand, it demonstrates how scientific facts emerging from labs influence the discursively mediated conceptions of nature and history and how they can have an impact on the production of biological difference. They act as devices of *interessement* in the sense that they form translations between DNA sequences and biological methods, presumptions about history, institutional settings as well as mediated public discourse (Callon 1999). Thus biohistorical narratives go significantly beyond metaphors and also beyond a Foucaultian concept of discourse in that they are conceptualised relationally and embedded in practice in as far as this is possible in historical research.¹⁵ The following sections focus on the particular narrative of "the European" and how it is translated into biomedical and social practice. Given the complexity and breadth of the issue, our account is necessarily sketchy pointing out in an exemplary manner the kinds of issues relevant in an in-

vestigation of classificatory processes as practice.

2.2 *Homo Europaeus*: hunter and gatherer

Biohistorical narratives denote stories about nature, narratives about inheritance, generation and evolution, which have become indispensable for the empirical life sciences, but are not being reflected as cultural presumption that are epistemologically contingent. The biological narrative about the European is a prominent example. Bioscientists report how Europeans have come to be what they are today; that today's Europeans decent from seven European molecular Eves (Sykes 2001) and, furthermore, not from peasant immigrants from the Middle East, but from native hunters and gatherers (Haak 2005); why they possess particular enzymes which predispose them to a particular health, a specific metabolism as well as certain nutritional needs, and how the latter co-evolved with agriculture and the domestication of plants and animals (Bloom/Paul 2005, Enattah 2002).¹⁶

None of these research concepts explicates which criteria have been recruited to select the "European". In most cases, it seems that the white skin colour would have been the foremost criterion. Accordingly, there are narratives about how, when and why European skin turned white: that is, under which circumstances it has been a selective advantage to possess a genetic make-up which did not favour the storage of dark pigments (Jablonski 2000). For each gene, which appears to separate the European from the non-European, such an evolutionary narrative is available.¹⁷

¹⁵ Of course, many would argue that metaphors, or language in general, as well as discourse, particularly of a Foucaultian provenience, already incorporate relationality and materiality. However, the mainstream in linguistics and post-structural social theory appears to take a rather more textual or symbolic perspective on the notion of the narrative.

¹⁶ For the latest findings on lactose intolerance and the surrounding discussions about uniqueness and Europeaness of mutations, see Burger et al. 2007.

¹⁷ Though, as to be expected, the findings do not stack up to an uncontroversial body of research. See e.g. Spielman et al. 2007 for some of the latest findings.

These narratives, however, do not remain confined to the rather narrow bounds of evolutionary biology. As empirically determined (and to a large degree naturalised) genetic differences, they translate into clinical practice where they are being used to differentially treat people, for example, in health services. Ethnicity is commonly seen and used as a phenotypic shortcut to the genetic make-up. BiDil exemplifies the pharma industry's interest in these developments (Kahn 2006). Questions about the "nature" of ethnic differences have thus again acquired significance posing fundamental new challenges for health systems with regard to observational practices, diagnosis and administration of treatment.

The concept of the biohistorical narrative exposes part of the translational work which goes into the production of naturalised accounts of human difference. Yet narratives alone would probably not suffice to bolster the plausibility of these accounts. To a significant extent, it is the routinisation of particular lines of thought in technical procedure and its locking in biological material *cum* technology which supports the reification of Euro-peanness in biological practice.

This process is exemplified by the genealogy and current use of the so-called Anderson sequence, i.e. the standard DNA sequence to measure genetic difference from the European. M'Charek reveals in a detailed laboratory study how the Anderson sequence is reified in work routines and treated as a neutral piece of technology representing standard European DNA (M'Charek 2005). She reports that leading geneticists admit that there is a racial bias in this neutral piece of lab technology: Instead of a European sequence, one might have chosen an African or Asian or Neanderthalian sequence as well, but since the first analysed sequence happened to be a European, it was just convenient to take this as a standard reference. A

closer look reveals that the Anderson sequence not only stems from different women but that at least one of them has been African-American. It is particularly due to these standardisation procedures that ethnocentric diagnosis or treatment regimes are often highly problematic.

Having lost this particular context, however, the Anderson sequence as a scientific tool enables the production of genealogical trees of the human species that are able to ignore the historicity of the sequence while giving an accurate historical insight into the development of the human species. Within evolutionary biology the Anderson sequence serves as a *standardised package*— an element of a material-discursive alignment which has become central to the study of human ancestry so as to largely escape further disciplinary reflection and questioning (Fujimura 1992). Furthermore, human diversity – or, more precisely, genetic differences between ethnic groups – is more than just an epistemic object in this context (Rheinberger 1997): it also gains the status of a technical object, or tool, that helps to investigate other objects of interest, such as disease distribution and ancestry, or to distinguish between 'criminal' and 'innocent citizen'.

2.3 Making up people

For single disciplines, such as evolutionary biology, the different aspects of the concept of the standardised package have been widely discussed in their many facets. Across disciplines, the theoretical repertoire narrows somewhat. While the concept of the epistemic object (Rheinberger 1997) and the immutable mobile (Latour 1995) are able to focus on the modes of production of distinct and stable alignments of knowledge, technology and materiality as well as their ability to travel and reappear in different contexts, less has been said about their reception and the effect they may have

on contexts within which they are reproduced.

The following section, therefore, briefly illustrates how medical research on obesity and cardio-vascular risk translates evolutionary biology into its own knowledge practices to strengthen particular hypotheses and aetiological models:

Overweight continues to trouble public health experts and molecular biologists alike (WHO 1998). Many aetiological models have been discussed without any of them fully able to explain the current increase or the distribution of weight across populations (Faith et al. 2002, Farooqi 2006, Rosmond 2005, Vitaliano et al. 2002). Since the mid-1980s, overweight is being discussed in the wider context of the metabolic syndrome: a statistical co-occurrence of metabolic and physiological parameters, i.e. weight, serum lipids, cholesterol, blood pressure and fasting glucose predisposing the afflicted to an increased risk of atherosclerosis, diabetes mellitus type II and cardiovascular disease (Kahn et al. 2005, Khunti/Davies 2005, Reaven 1988). The existence, definition, utility and diagnosis of the syndrome are being fiercely debated.¹⁸ The genetics of the syndrome has become increasingly important over the last five to ten years in line with a general expansion of research efforts at the level of genes and the genome (Hughes/Aitman 2004, Illig et al. 2005, Roche et al. 2005, Shmulewitz et al. 2006).¹⁹

¹⁸ The controversy is currently being investigated from a science studies and ethics perspective (Chatterton October 2006). See also Niewöhner 2007.

¹⁹ Particularly the implication of insulin resistance in the syndrome's aetiology supported a molecularisation of the research landscape as the metabolic syndrome became attractive to the diabetes research community, which already had a significant interest and research capacity in the genetics of insulin action (Ahima et al. 2006, Bjorntorp 1995, Gil-Campos et al. 2004, Hughes/Aitman 2004). Furthermore,

Intricately linked to this rise of genomics research are questions about the transmission of disease relevant factors between generations and, consequently, questions about the evolutionary basis for current diseases and their distribution. This is where the biohistorical narrative about the European hunter gatherer enters the frame. While the so-called "thrifty gene" hypothesis had been developed already in 1962 as a general concept (Armitage et al. 2004, Neel 1962), it re-emerged during the 1990s as a more specific explanatory model to understand the differential increase and distribution of weight across the globe. According to this hypothesis, the early Europeans were striving through Europe hunting and gathering. Those with a high fat storage capacity had a selective advantage in an environment of variable nutritional supply. Hence genomes were selected for in the human population that favoured rapid fat storage. With the change to a modern, Western lifestyle, marked by a continuous nutritional supply and little effort in the acquisition of food, the thrifty genotype has now turned from a selective advantage to a maladaptation predisposing the carrier to a higher risk status. Those of us that put on weight easily are presumed to possess this thrifty genotype. This hypothesis has been further developed to include a thrifty phenotype (Hales/Barker 1992) determined by imprinting processes through behavioural and environmental influences within and across several generations (Griesemer 2002, Jablonka/Lamb 2002, Vijver et al. 2002).

The concept of the hunter gatherer shifts from evolutionary biology into biomedical research and epidemiology

advances in the understanding of adipose tissue as hormonally active (Hutley/Prins 2005, Rosmond/Bjorntorp 2001) have been influential as has an increasingly systemic understanding of the involvement of peripheral and central nervous activity (Bjorntorp 1999, Richard et al. 2002).

and is confronted with a totally different set of assumptions. Whereas the Anderson sequence, concepts of drift, mutational clocks and selection made up the context for the hunter gatherer in the evolutionary biology labs, the translated European hunter has become a fact, a naturalisation and reification of history in biomedical research, which is able to increase the plausibility of certain arguments about the interactions between genetic predispositions and lifestyle in modern societies. If the hunter gatherer narrative were not available, it would be more difficult to argue the case: settled peasants who moved into Europe, for example, would have had less difficulties in maintaining a constant food supply. Thus a thrifty gene would not be such a selective advantage. It often seems to be the intuitive plausibility of many evolutionary accounts as well as its ability to act as a boundary object (Star/Griesemer 1989) supporting translation processes across diverse research practices, which makes these broad sweeping hypotheses so immensely powerful in scientific as well as public discourse.

This brief illustration emphasises how the context within which the concept *hunter gatherer* has been initially produced is not simply lost. Rather, it remains a somewhat abstract and implicit source of legitimacy, which is able to resonate with different research practices.²⁰ They meander between a mere metaphoric use and an ability to organise a way of seeing the research field, generating hypotheses

and influencing study design. While they help to legitimise a particular dynamic in biomedical research, it is crucial to note that this new context is not able to break up the routinisation of the concept and reflect the implicit assumptions inherent within it. Rheinberger lucidly analysed how epistemic objects oscillate between routine use and epistemological questioning (Rheinberger 1997). This works within disciplines because the context within which the object operates is intact and the assumptions can usually be made explicit. Once the object has been standardised, packaged and translated into a different disciplinary context, the possibility to reflect the implicit assumptions is largely lost. Biomedical researchers are not sufficiently familiar with the methodological and theoretical development of evolutionary biology so as to be able to return the standardised package from routinisation.²¹

Rather than critiquing this form of evolutionary translation, then, we *follow the actant*, i.e. we briefly turn our eye to the effect of the hunter gatherer on diagnostics.

²⁰ John Law has pointed out that the creation of presence necessarily creates absence or othering as well (Law 2006). Here, the presence of the hunter gatherer as factual knowledge others the uncertainty attached to the concept in evolutionary biology. In a more systems theoretical language, one might consider different research practices as operationally closed systems, which develop something akin to structural coupling (Luhmann 1983) in order to handle increasing external complexity and create legitimacy.

²¹ A point in passing: Latour has written about the concept of the *faitiche* (Latour 2002) to reveal that it is indeed the conventional constructivist position which reinforces the naturalisation of scientific fact. The constructivist argues that it is him who reveals to the positivist that his fetish-like object is merely a social construction; that if only he stopped believing, he could see what lies behind the construction, namely a particular social constellation. Of course, by so doing, he is blind to the fact that the science community does not invest ontological belief in its objects: they merely work in practice. Thus telling the scientist about the social constructedness of their objects makes little difference to most. Social scientific analyses thus need to accept the contingency (Rorty 1989) of scientific practices as a starting point from which to investigate the unresolvable entangling of representation, production and materiality as well as its consequences.

Figure 2: Ethnic Stratification of Waist Circumference

source: International Diabetes Federation:
Diagnostic Criteria for Metabolic Syndrome 2006

Country/Ethnic group		Waist circumference† (as measure of central obesity)
Europeids*	Male	≥ 94 cm
	Female	≥ 80 cm
South Asians**	Male	≥ 90 cm
	Female	≥ 80 cm
Chinese	Male	≥ 90 cm
	Female	≥ 80 cm
Japanese***	Male	≥ 85 cm
	Female	≥ 90 cm
Ethnic South and Central Americans		Use South Asian recommendations until more specific data are available
Sub-Saharan Africans		Use European data until more specific data are available
Eastern Mediterranean and Middle East (Arab) populations		Use European data until more specific data are available

* In the USA, the ATP III values (102 cm male; 88 cm female) are likely to continue to be used for clinical purposes

** Based on a Chinese, Malay and Asian Indian population

*** Subsequent data analyses suggest that Asian values (male, 90cm; female 80cm) should be used for Japanese populations until more data are available.

† In future epidemiological studies of populations of Europid origin, prevalence should be given using both European and North American cut-points to allow better comparisons.

Although a higher cut-point is currently used for all ethnic groups in the USA for clinical diagnosis, it is strongly recommended that for epidemiological studies and, wherever possible, for case detection, ethnic group specific cut-points should be used for people of the same ethnic group wherever they are found. Thus the criteria recommended for Japan would also be used in expatriate Japanese communities, as would those for South Asian males and females regardless of place and country of residence.¹¹

The International Diabetes Federation concerned with and about the current obesity epidemic is keen to improve early diagnosis of metabolic changes in order to intervene as preventively as possible with lifestyle changes and drug-based therapy. The current booklet on their worldwide consensus definition of the metabolic syndrome (IDF 2006) includes waist circumference as one of five diagnostic criteria. This in itself is highly controversial, as body mass index and waist to hip ratio are also being put forward as the more powerful indicators, but not unusual (NCEP 2001, WHO 1998, 1999).

Unusual is the ethnic stratification of waist circumference shown in figure 2.

These ethnically sensitive cut-off points are based on epidemiological data from various sources rather than biomarkers indicating a thrifty genotype. Yet the thrifty gene hypothesis strengthens the role of genetic predispositions in aetiological debates and, combined with the hunter gatherer narrative, suggests that genetically different subpopulations will display different rates of obesity and cardiovascular disease. It thus favours an ethnic stratification of diagnostic criteria over a range of others that might be equally suitable and readily available, for example: socio-economic status.

While statistical data can never make any claims about individuals but must

necessarily remain at the aggregate level of populations, the translation of evolutionary biology into biomedical hypotheses and into global clinical guidelines acts as a classificatory device in the sense of Hacking's *making up people*. The production of an individual cardiovascular risk profile through an anamnesis at the local general practitioner including a conversation, biometrics and standard lab test links the individual to a global disease distribution. It translates population risk into a personal fact if not danger with very real consequences.²²

2.4 Biosocialities

Hacking argues that *made-up people* understand their new identity as a way to be a person. He refers to this interactive dynamic as the looping process (Hacking 2006). Hacking argues that whereas classifications such as autism, multiple personality disorder and homosexuality could at different times serve as ways to be a person, obesity will remain a mere attribute of a person rather than a determining characteristic.

We take a different view. Certainly, obesity in its non-clinical forms does not seem to interfere with everyday life as much as autism seems to do. There are no particular treatment regimes disrupting day-to-day practices as with many other chronic diseases; obesity does not really interfere with a person's ability to partake in working life, and perceptions and experiences of the self need not be massively altered to bring together body and self-images with appearance and possible social roles.

However, it seems to us too narrow a view to focus only on the medical-scientific element of a classificatory process. Neither the classificatory process itself nor the responses are driven purely by changes in a scientific

rationale. Instead, both are entangled in wider issues of changes in social, political and moral order. The dynamic interactions of classificatory processes usually occur within a series of wider shifts involving public perceptions, institutional responsibilities and moral attributions.

From a social anthropological perspective, obesity as part of the metabolic syndrome has become not only a different diagnosis but the most important risk factor for cardiovascular disease; a disease that kills an estimated one million people each year globally and already binds around 7% of annual national health spending in the industrialised world. Primary prevention and health promotion have been identified as the most important strategies to get control over the 'obesity epidemic' (Apitz/Winter 2004, Walter 2004, Windler et al. 2004). Prevention in individual terms essentially means a change to a more sustainable lifestyle including exercise and a moderately caloric diet. Prevention in institutional terms means intervention. While this has become a global effort that reaches from a WHO charta via an EU white paper to national guidelines (WHO/EU 2006), the German health minister has indicated that the solution from her perspective will not lie with national sanctions such as a tax on fat, television or cars (Walter/Scriba 2004), but with individually tailored local solutions administered via the health insurers.²³ Coercion, this lesson has been learned, does not work well within a state the people of which perceive themselves and their approach to governance as liberal. Yet, as a consequence, the focus is firstly on a kind of prevention which seeks out those people who traditionally do not respond to appeals to self-management ('aufsuchende Prävention'). Secondly, this liberal regime of intervention firmly

²² On the discussion of risk and danger in diagnostics, see also (Aronowitz 1998).

²³ Presentation at "Berliner Republik, InnovationsDialoge" November 2006, Hotel Alexander Plaza, Berlin, Germany.

rests on a view of the individual as a *homo oeconomicus* (Kirchgässner 1991), as a self-regulated subject trying to optimise its own life by rational choice.

The implication of this is not only an increasing pressure on individuals to conform to medical and economic rationalities. More importantly, in its rhetoric it also conveys a strong moral message: not losing weight and starting to exercise despite better knowledge is a wilful disregard of the community of solidarity that is our society. To economically and morally sanction this kind of deviance has become the explicit target of many who advocate setting approaches to prevention, for example, at the workplace: it can no longer be *cool* to ignore health promotion efforts at work; instead, it needs to be a decision, which is sanctioned by the peers as an attack on their wallet and solidarity in itself.

It is clear from these impressions that classification as overweight or *at risk* is not merely a medical process but increasingly strongly loaded with social and moral meaning. It is, then, easier to see how being overweight can quickly become a way to be a person. Also, it is in this wider context of prevention that the hunter gatherer and its translations into ethnicity-bound regimes of difference enter into social practice beyond individual practitioner patient encounters. The US American National Association for the Advancement of Colored People (NAACP) has started to offer fitness programmes to its members to counteract the obesity problematic in its community. The association's president announced in his opening speech for the annual congress in 2006:

"...We've got a Freedom Fighters Fitness Challenge. Go to the workshops, check it out. It speaks to obesity, and it speaks to the fact that there is a higher percentage of obesity in our communities than there is in the majority community. And we know all of the bad things that go along with obesity, like diabetes, and high blood pressure,

and heart disease. And we know that we've got it, right."²⁴

Though this appeal carefully avoids any reference to genetics, the statement "we've got it" at least implies also a biological component. Other materials by the NAACP make the appeal even clearer:

"With genetic predispositions coupled with poor diet and little to no physical activity, these numbers will only increase."²⁵

Here, the hunter gatherer appears as the risk to a specific ethnic subpopulation, which then needs to respond. And it does respond as a community with a genetic predisposition. The fact that ethnicity may not be a sensible marker, that by far not everyone 'in the community' is affected and that more likely than not a whole range of other factors are significantly implicated in producing increases in cardiovascular risk, are sidelined. The hunter gatherer, while running across a number of social ordering effects, is translated into community practice.

A very different story is told by the manifold nationally and internationally organised associations to advance fat or size acceptance, such as the National Association for Fat Acceptance or the International Size Acceptance Association (similar groups exist across the world). Here, the impetus is primarily on resistance to the moral connotations and the stigmatisation that increases around overweight – the kind of resistance Ian Hacking presumed would not happen because being fat is not a way to be a person. The science that links overweight to cardiovascular disease is disputed on the grounds that it is parameters usually associated with overweight rather than overweight itself, which lead to cardiovascular disease. As a consequence,

²⁴ Bruce S. Gordon addresses the 97th NAACP Convention, 2006. <www.naacp.org> last accessed 27th of April 2007.

²⁵ San Jose Chapter NAACP health watch <<http://sanjosenaacp.blogspot.com>> last accessed 27th of April 2007.

groups such as the above advocate a mobile lifestyle, which does not worry about weight. At the same time, many of them point to what they perceive to be work showing an increasing genetic basis for overweight and consequently argue that it is unhelpful to act against a biological reality. Here, the thrifty genotype translates not into a threat to a community but into an important driver in a complex politics of identity.

These two examples give a small flavour of the complex constellations that arise from translations involving medical practice, made-up people and social bodies. The concept of somatic individuality has already pointed to the increasing role of the body in producing selves (Novas/Rose 2000). It is, however, in the age of biosociality that medical, moral and political intervention logics increasingly blend into each other while controlling populations and shaping their nature according to cultural presumptions (Rabinow 1992). Biopolitics finds an ally in the governance of the soma (Beck/Niewöhner 2006).

3 Looping

In his original writings on looping, Hacking suggested more strongly than in the later lectures that a loop would imply an adjustment of the original classificatory categories (Hacking 1999). This closing of the loop was difficult to imagine from a science and technology focused perspective. The scientific community is not set up to receive feedback from those it classifies. The public understanding of science and humanities approach illustrates that, in some circles, this is not even perceived to be desirable. Yet understanding classificatory practices as translations in the way we have tried to show in the previous sections offers a new way to think the loop. Rather than looking for clearly delineated pathways from the classified back into science, it is via the entangling of the classificatory processes in political,

moral and economic practices that science remains engaged with the classified. This entanglement can take on easily visible forms, such as research priorities and funding, insurance companies putting specific drugs on their positive lists or media reporting.

Even more importantly though is the less visible shifting of translations that has to do with implicit understandings of statehood, individuality and sociality. These shifts render possible certain interventions and foreclose others. They make particular research avenues appear more likely and strengthen certain alliances while lessening others. In a somewhat different context, Hacking argued that the "taken for granted may have a greater effect on our sense who we are, or what it is to be a human being, than amazing achievements on the margins of our existence" (Hacking 2006). We take this as an invitation to further empirical work on translations in the banality of everyday life.

Seen from a historical perspective, looping effects have occurred since the end of the 19th century, when biological disciplines began to gain a greater impact on social processes. Classifications of human diversity have been used ever since to intervene in the biological make-up of populations by setting up laws, marriage counselling services, regimes of health and racial hygiene. The outcome of new loops as described above are yet unclear; however, neither cardiovascular risks nor fatness nor human diversity will remain what they are considered to be today, and this might be due to looping effects similar to those we have discussed.

4 Concluding discussion

We hope to have shown how translations produce human diversity in late modern societies as well as the different roles biohistorical narratives, stan-

dardised packages and forms of resistance and appropriation play within these. We have put a particular emphasis on the multiple entanglement of different knowledge practices across scientific disciplines as well as advocacy groups and sociality. And we have taken the social and historical contingency of practice as a starting point to move beyond constructivist relativism in order to take seriously the patterning of practice which arises from the constraints of socio-material alignments.

In our argument, we have sidelined issues of power and politics to an implicit role. While our historio-ethnographic approach would also support an analysis focused on the governance of human diversity and the implications for self-regulation and intervention, this has not been our point and we believe that it does not invalidate the analysis we presented here.

More importantly, however, it is not clear whether we have succeeded in a symmetrical analysis that (re)introduces materiality into social analyses. As far as technological and biological artefacts are concerned, we have given non-intentional agency to scientists and pressure groups, standardised cell lines and ethnically sensitive diagnostic criteria. This may count as fulfilling Latour's call for symmetry to some degree.

We have also employed the concept of translation to problematise what we believe to be dynamic socio-material practices, namely the co-production of diversity through technology, biological material, scientific practice all entangled in a wider socio-cultural context. We thus hope to contribute to a diffusion of modern dichotomies by focusing on a co-productive rather than a binary vocabulary.

Yet, while we are able to support notions of somatic individuality (Novas/Rose 2000) and biosociality (Rabinow 1992), we have failed to properly in-

corporate the 'body biological' into an historical and social scientific analysis. Further work is ongoing at Humboldt-University and the Charité Medical School to bring physiological parameters into contact with psychometric data and ethnographic reporting of everyday life. We are thus committed to take symmetry seriously and further investigate the multiple entanglement of the biological body, perceptions and experiences of the body as well as representations of the body.

Such an analysis can only succeed if it is embedded within a framework of research that is at the same time clearly focused on disciplinary perspectives and broad enough to integrate findings into a wider historio-ethnographic picture of social practice. This is, we believe, only possible in an interdisciplinary setting that operates beyond constructivism and with an ironic appreciation of contingency.

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The role of public policy in promoting technical innovations.

The case of the regional innovation network InnoPlanta

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Abstract

The purpose of this article is to demonstrate and to discuss on the basis of an in-depth case study the range and limitations of public policy aiming at promoting the development of regional innovation networks and clusters. This is done first by denominating main criteria, potentials and problems of a public policy promoting regional clusters (section 1), second by describing the development of the network association InnoPlanta and its major framework conditions (sections 2 and 3), third by summarizing the actor constellation of the network and the innovation pattern and market perspectives of InnoPlanta's research projects (sections 4 and 5), fourth by then pointing out the structure and role of public promotion policy in this process (section 6), fifth by comparing promotion objectives with results achieved (section 7), and sixth by drawing some conclusions concerning successful promotion policy in the case investigated and in general (section 8).

As shown in the case study, the role, success or failure of public policy promoting the development of regional innovation networks and clusters depend on its favourable interaction dynamics with the existing social and economic contextual conditions. Therefore, referring to the in-depth case study of Conrad (2005), on the one hand these framework conditions are sketched in somewhat more detail, and on the other hand the article does not focus on one specific theoretical question, but tries to combine various analytical perspectives to explain the role and success of public promotion policy in the case of InnoPlanta. Consequently, this article concentrates on explaining the role of the BMBF InnoRegio program, in particular, for the development of the regional innovation network InnoPlanta, and not on this type of public promotion policy per se.

1 Introduction: promoting regional clusters

Addressing in general terms main criteria, potentials and problems of a public promotion policy striving for the creation of innovative regional clusters, first the respective key terms are specified in more detail.

According to Meyer-Krahmer (1999: 43), technology and innovation policy¹ aims at

- the formation and shaping of the research landscape of a country,
- the generation of favourable financial and other framework conditions for basic research, long-term application-oriented research and industrial research,
- the building and shaping of an innovation-oriented infrastructure,
- and the conscious and sometimes unconscious influencing of technology development towards certain goals (competitiveness, living circumstances, infrastructure, long-term programs).

Instead of steering technology development, it is actually rather caused by it due to systematic reasons. Since it cannot directly steer research and development processes at a substantive level, it addresses research institutions, i.e. formal organisations and not research activities themselves (cf. Daele 1989, Schimank 1991).

Innovation networks may be conceived of as inter-organisational social systems which achieve technological and organisational formation of (their) structure by positive self-reinforcing feedback mechanisms, and they are necessarily cognitive networks which aim at the solution of a task and not just at balancing and coordinating

their interests. Regional innovation networks denote networks concentrated in one region with the primary aim and task – according to their own reasoning – to produce innovations by utilizing regional competencies and communication.

Cluster presuppose the existence of regional networks (at least in a wider sense), but may well be limited to sector-related actors and arrangements of a region. Particularly, in newly emerging markets a local sector-specific cluster develops if the critical mass is transcended in a region resulting from sector-specific company agglomeration in a region and sufficient local circumstances. Typically few key persons coordinating different activities in the region play an important role. Cluster formation depends on the interplay of appropriate sector-specific conditions (in particular accumulation of human capital, new start-up firms, innovation-oriented sectors, synergies between firms, and disposable venture capital), a favourable market situation², and the existence of corresponding actors and networks.³ Additionally, sufficient regional boundary conditions are required, such as a local infrastructure, the ability of local actors to found new companies, the availability of services and the existence of relevant public education and research institutions (cf. Blind/Grupp 1999, Brenner/Fornahl 2002).

As the success of regional innovative networks and clusters crucially de-

¹ Innovation policy can be seen as the integral of science, education, research, technology and public policy (initiatives) oriented towards industrial modernisation in order to improve the competitiveness of a (national) economy or of selected sectors.

² "Ein neuer lokaler branchenspezifischer Cluster entsteht in der Regel, während der Markt für die Produkte der Branche stark anwächst... Darüber hinaus kann eine Clusterbildung durch eine Öffnung des Marktes hervorgerufen werden." (Brenner/Fornahl 2002:27)

³ Regional entrepreneurship and networks play an important role as promoters concerning initiation and success of cooperation and coordination processes during the development phase of a local sector-specific cluster by acting as germ cell and example for other actors and getting them to cooperate. (Brenner/Fornahl 2002:28)

depends on the interaction dynamics of relevant influencing factors, its pathway and modality should be investigated, conceptualised and modelled. However, corresponding attempts are hardly found in social science research and literature, e.g. on regional innovation networks.

Concerning the possibilities and limitations of a promotion policy striving for the formation of self-supporting regional innovation networks and clusters, the following conclusions seem to be justified according to Brenner/Fornahl (2002)

(1) Public policy can stimulate and promote the formation of (regional innovative) clusters, but cannot generate them itself. To enlarge the probability of their formation mainly measures to improve the (regional) infrastructure appear to be appropriate, e.g.

- the establishment or improvement of (continued) educational institutions;
- the support or improvement of the framework conditions for setting up new companies;
- the establishment of research institutions or direct support of innovation processes;
- the improvement of (regional) infrastructure for companies.

These measures should be executed in accordance with regional and sectoral objectives. In most cases the effective application of policy measures is only feasible at certain points in time in certain places. Therefore promotion policy should be limited in time until a cluster formed in less than a decade, and should take into account the systematically limited number of (possibly) successful regions as geographical locations of regional innovation networks and local sector-specific clusters.

(2) Promotion policy may influence the sites as well as the strength of a cluster. However, policy-making has only limited steering know-how due to in-

formation deficits and high transaction costs (cf. Keck 1987).

As a result, the probability of successful policy measures increases if politics does not intervene as an external authority, and if it develops, instead, coordination processes and problem solving capabilities together with the regional actors concerned in order to adapt them to regional and sector-specific characteristics.

Not every measure must be executed at the same policy level; instead various political actors may intervene – in a supplementary manner – with different measures at the same time. This requires close cooperation and coordination between the participating policy levels. Since regional actors may react differently to promotion policy, additional pick-up effects (*Mitnahmeeffekte*) have to be avoided as far as possible by appropriate organisation of promotion measures.

(3) Concerning the four preconditions of cluster formation described above, improving regional boundary conditions constitutes the best possibility for promotion policy to have significant effects.

In said conditions, apart from the support of innovation processes the most effective measures are the ones to educate labour force and to create sector-specific infrastructure. A further measure is to support the foundation of companies immediately after the formation of a new market. Promotion policy has much less chances to influence sector-specific self-reinforcing processes, at least as long as the state is not able to act itself as buyer. Similarly, the foundation of regional firms can only be supported by indirect measures aiming at regional communication and diffusion processes. Furthermore, attitudes and opinion of the population mainly depend on cultural aspects and on structures having already developed in the past so that policy can influence them weakly at best.

On the one hand, promoting innovative (regional) clusters is politically attractive, because a major result can be achieved with relatively small efforts if the preconditions of cluster formation described above are given, because promotion policy can be limited in time for good reasons, and because it can expect additional indirect positive effects on competitive and innovative capabilities and regional development in general.

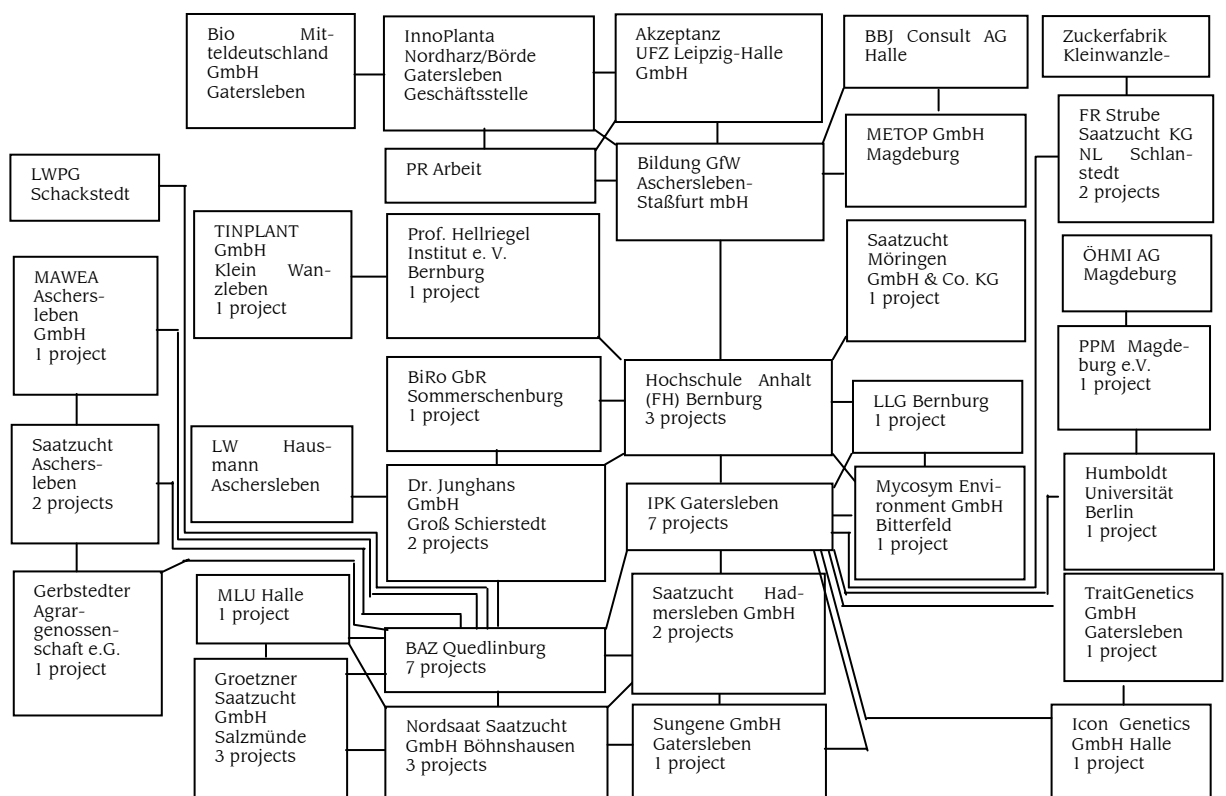
On the other hand, a promotion policy aiming at connecting global innovations with regional competencies is in conflict with a regional policy aiming at equal living conditions and standards, as the former sharpens inter-regional gradients by the successful development of promoted regions.

2 Development of InnoPlanta

Like most of the rural areas of the eastern German states, the region Nordharz/Börde, situated between Magdeburg and Quedlinburg, can be characterised by low economic strength and dynamics and high rates of unemployment. It has at its disposal, however, a long and continuous tradition and expertise in the field of special cultures, cultivating spice and herbal plants, and seed cultivation, supported by respective favourable climatic conditions. This is important because internationally competitive plant breeding is the bottleneck of the economic implementation of the potentials of plant genetics (Voß et al. 2002).

In the late 1990s *regional* efforts were started to improve in a medium-term perspective the economic power of the state of Sachsen-Anhalt by goal-oriented support and coordination of

Figure 1: Cooperative networking of project partners within InnoPlanta



Source: InnoPlanta secretariat

research, development and the opening up of new markets in the field of new biotechnologies on the basis of these regional traditions and competencies. These regional efforts met with the InnoRegio program of the *federal* ministry for education, research and technology (BMBF), a program for supporting – on a competitive basis – the self-organisation of regional innovation networks in the eastern German states. It was based on the intention to advance economically promising research and development in cooperative arrangements of local industrial companies and research institutes by providing corresponding seed money in the InnoRegio program of altogether 255 Mio. € over a period of five years (BMBF 2000).

The InnoPlanta association, newly founded in 2000, initiating, organising and administrating corresponding regional research efforts and networks of its members in plant biotechnology, became winner of that InnoRegio competition and received about 20 Mio. € between 2001 and 2006.

The cooperating actors from science and industry, participating in approximately 30 funded plant biotechnology R&D projects, mainly organised themselves as a regional innovation network in order to receive public funding for their research interests, and therefore considered themselves reasonably as a kind of pork barrel. Figure 1 represents the corresponding institutions involved in the InnoRegio InnoPlanta, including the number of R&D projects pursued, and indicates cooperative arrangements between them in 2003 by lines connecting cooperating actors. Typically substantive intense communication among the cooperating partners is mainly taking place at the level of the different specific research projects. Apart from the necessary scientific-technological breakthroughs their chances for success crucially depend on associated competitive advantages at the global level, on the economic power and position

of the participating enterprises, and on the medium-term implementation of green biotechnology in Europe. At present the latter is only realised to a very limited degree because of lacking acceptance by consumers (cf. Gaskell et al. 2003, Hampel 2004) and, until recently, by a de-facto moratorium of genetically modified food and partly field tests of genetically modified plants at the EU level.

Significantly, none of the R&D projects of InnoPlanta aims at developing any genetically modified food products, though mainly because of the then necessary huge development costs. Instead, they focus on new molecular genetic processes for plant breeding, on breeding of new resistances against important European pests in the major crop plants, on breeding of cultivated plants containing new components, and on the breeding optimisation of regionally important special cultures.

In general, the ongoing R&D projects either aim with a strong scientific orientation at the development of innovative biotechnological processes, or at niche markets by improving spice and herbal plants and regionally important cultivated plants with the help of plant biotechnological products and processes. Project costs vary between 260.000 € and nearly 5 Mio €. Subsequent market penetration of successful R&D projects typically can be expected 10 or more years after their beginning (Conrad/Steuer 2003).

During the first years (2000 – 2002) the learning process of major science-based network actors, especially of the centrally positioned plant biotechnology research institute IPK Gatersleben (Institut für Pflanzengenetik und Kulturpflanzenforschung), to (re)orient their publicly BMBF-funded R&D projects from basic research in biotechnology to market-oriented R&D projects with genuine participation of local industrial companies contributing their own financial means, too, turned out to be troublesome and painstaking.

ing. The reason for this was the trade-off between their genuine scientific research interests and the pressure of the funding ministry and its associated research project management body Jülich, which is responsible for final funding decisions and project control, towards marketable development products. Nevertheless, the largely BMBF-funded InnoPlanta project scheme helps to initiate and to push regional contacts and possible future cooperative market-oriented R&D projects of scientific and economic actors.

Figures 2a and 2b give a condensed overview over the (prospective) development process of InnoPlanta over time for the past (1997-2004) and for the future (2004-2020), assuming its economic success. The figures indicate the interaction dynamics of key development determinants at the macro-, meso- and micro-level.

At the *micro-level*, over time the development of InnoPlanta as an innovation network is pointed out as resulting from its internal development dynamics; at the *meso-level*, the major regional political and economic actors and boundary conditions can be observed; and, finally, at the *macro-level*, the general (national and global) policy programs, conflicts and regulatory arrangements as well as key developments and market structures in plant biotechnology are listed. As indicated by the positioning of corresponding boxes in figures 2a and 2b, InnoPlanta and its members and additional relevant actors form the essential actor constellation which decides on and is responsible for project performance, follow-up developments and founding of biotech-start-ups.

Up till now, four phases of InnoPlanta's development – described in more detail in Conrad (2005) – may be distinguished: rise and foundation (1999-2000), establishment and formation of the structure (2001-02), consolidation and routinization (2002-04), and optimisation and continuation

(2004-06). Obviously, policy influence only plays a limited role, effective mainly in the beginning of network development. Currently, the sketched development process of InnoPlanta is somewhat below the top of figure 2b. After the InnoRegio program ended end of 2006 InnoPlanta continues to acquire and perform plant biotechnology R&D projects, though at a lower level of funding and still without significant income from selling its own genuine products on the market.⁴

3 General framework conditions

Four main general framework conditions which are specified below, determine the range of InnoPlanta's possible development paths and innovation success:

- the general conditions of success for regional innovation networks and clusters;
- the innovation dynamics of plant biotechnology at the global level;
- the biotechnology policy and regulation, as well as low social acceptance of genetically modified food in Germany;
- the BMBF-InnoRegio program for the eastern German states and the regional biotechnology policy in Sachsen-Anhalt.

Cluster formation depends on appropriate sector-specific conditions, a favourable market situation, the existence of corresponding actors and networks, and sufficient regional boundary conditions (cf. Brenner/Fornahl 2002). At the level of actors, successful development of innovative networks requires a common objective, appropriate forms of organisation and communication, the necessary performance capability of participating actors, the existence of complementary competencies, and the

⁴ This article was mainly written in 2005/06, and revised early in 2007.

Figure 2a: Model type development dynamics of InnoPlanta (past)
 BT=biotechnology, NW=network, GfW=Gesellschaft für Wirtschaftsförderung

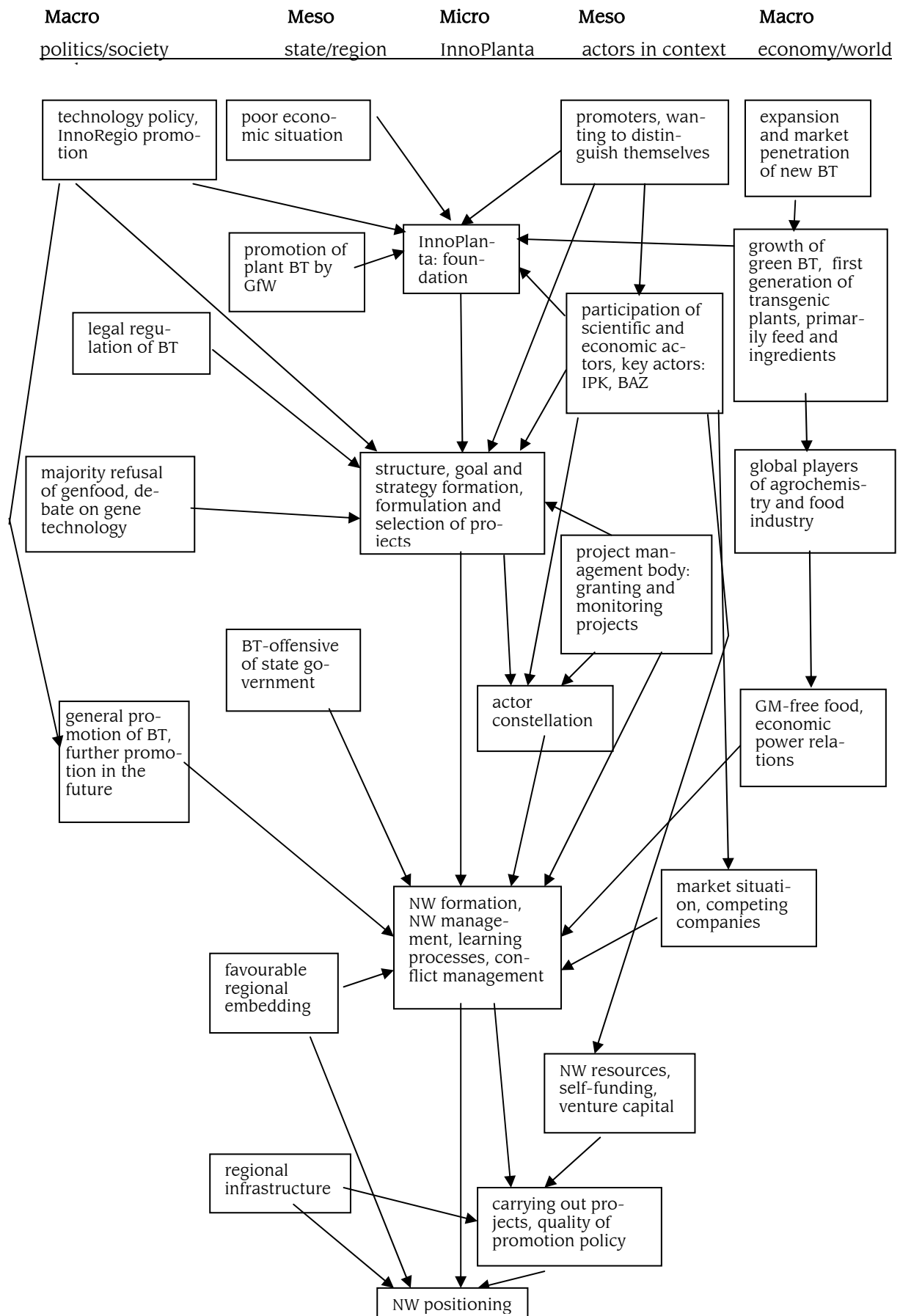
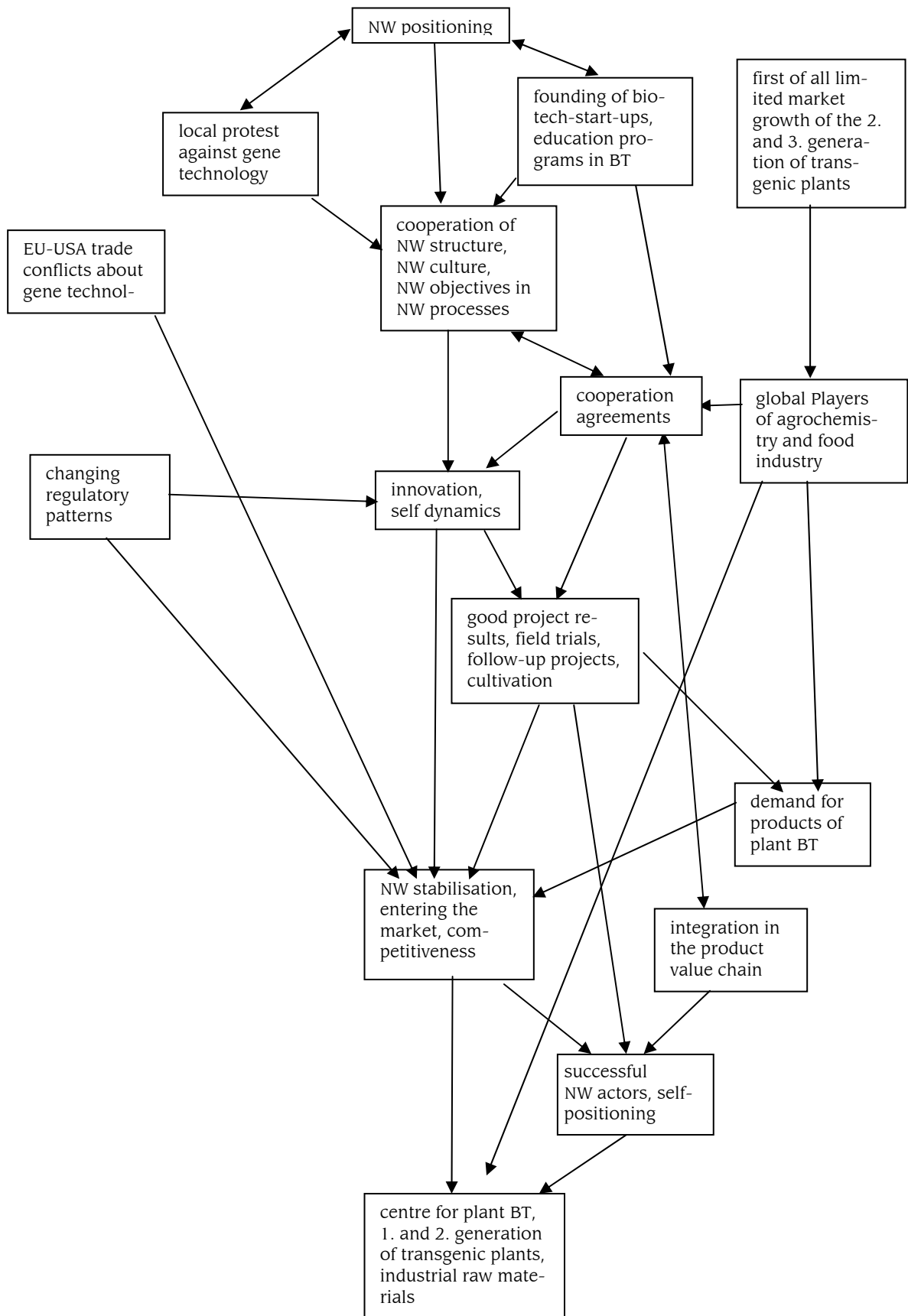


Figure 2b: Model type development dynamics of InnoPlanta (future)

BT=biotechnology, NW=network,

Macro Meso Micro Meso Macro
 politics/society state/region InnoPlanta actors in context economy/world market



capacity to bring them into innovative projects (Eickelpasch et al. 2002). These conditions meanwhile can be seen as fulfilled to quite some degree in the case of InnoPlanta.

The expected mid- and long-term commercial potentials of agrobiotechnology are considered multifarious in spite of current low acceptance of many products (Menrad et al. 1999). Different areas of applying plant genetic engineering have to be distinguished (cf. Voß et al. 2002), such as improvement of agronomic properties, food-oriented utilization or industrial raw materials. Growth rates and profitability of GM (genetically manipulated)-based output properties and even more of molecular farming are considered much higher than the ones of GM-based input properties⁵, and already for 2010 their market potential is optimistically estimated fivefold the latter one (cf. Kern 2002, Vogel/Potthof 2003). So, in principle, the application possibilities and perspectives of plant biotechnology can be judged as manifold and positive. Whereas many mainly diagnostic and technical methods of breeding using gene technology are already well established, the manifold and broadly utilized creation and diffusion of transgenic plants, however, remain questionable for the foreseeable future because of economic, technical and biological reasons (Vogel/Potthof 2003).

The development of transgenic plants lasts 6 to 12 years. The chance of market introduction of a successful laboratory development is less than 1%.

⁵ GM-based input properties stem from intentional changes of plants in one or two genes in order to influence their cultivation and yield, i.e. their agronomic properties, but not the quality of the final product itself. GM-based output properties refer to intentional changes of existing metabolic processes or to the addition of new metabolic processes by changing or adding several plant genes in order to change food properties. Molecular farming aims at utilizing plants for producing non-plant products such as pharmaceuticals or vaccines.

Development costs amount to about 50 Mio. €. Without large markets allowing rapid return on investment these development costs and additional costs of separate harvest and identity preservation are too high. However, the demand of these transgenic plants frequently is not secured, particularly as long as the food industry pursues a strategy of GM-free food.

Furthermore, the insertion of several alien genes and their tissue- and stage-specific expression with the help of specific promoters is a difficult, technical enterprise prone to failure, since the intervention into complex and well balanced metabolic processes easily leads to unwanted side effects.

Therefore the input properties of herbicide tolerance and insect resistance in few relatively easily transformable cultivated plants, i.e. soy bean, corn, canola and cotton dominate the market of transgenic plants. Plants with GM-based output properties were hardly licensed and offered on the world market in 2003, but may have a larger share after 2010.

In sum, commercial cultivation of transgenic plants with these new input properties has rapidly expanded to 102 million hectares in 2005 after its start in 1996, though concentrated in few countries: USA, Argentina, Canada, and meanwhile Brazil, India, China, too. However, diffusion of the second generation of transgenic plants with GM-based output properties should be expected only gradually and to a limited extent, involving a higher risk of (economic) failure. So the innovation dynamics of plant biotechnology at the global level tends to be a potentially highly favourable, but still relatively uncertain contextual framework condition for InnoPlanta.

Whereas red biotechnology meanwhile is socially more or less accepted and used in Germany – with the exception of genetic manipulation and utilization of human beings themselves –, the utilization and regulation of green bio-

technology are pushed by the actors involved in its development, on the one hand, but are confronted with severe restrictions in Europe, on the other hand. These restrictions mainly stem from the combination of the following circumstances. The release of GM-plants and the import of genetically modified food in fact were largely prohibited because of the de facto EU-moratorium 1998-2004, resulting from strong political controversies in the mid 1990s. Additionally, food and feed containing at least 0,9% of substances, which are changed or produced by genetic engineering, have to be labelled correspondingly since 2004.

Furthermore, consumers can bring to bear their scepticism or non-acceptance of genetically modified food in particular, in an economically effective manner. Since the late 1990s food producers, trade and retailers in the EU pursued corporate strategies to produce and offer only (certified) GM-free food and thus contributed to blocking green biotechnology in the food sector up to the present.

In view of its multifarious potentials, its forced utilization in increasing parts of the world, and the vested interests of its promoters in agrochemistry and parts of agriculture, an ongoing longer term hindrance of green biotechnology seems unlikely, as long as no grave accident attributed to gene technology occurs. It will also remain unlikely as long as trade-conflicts and costly labelling and separation prescriptions do not make GM-food and -feed economically unviable (cf. Bernauer 2003, Paarlberg 2003, Young 2001). Thus, biotechnology policies and regulations, and lacking social demand for genetically modified food tend to partly delay plant biotechnology development processes and to restrict them to non-food properties and products, but do not prevent them *per se*. This is well reflected in the plant technology development path followed by InnoPlanta.

Finally, as shown in sections 6 and 7, public promotion and funding of (green) biotechnology by the InnoRegio program of the BMBF (see cf. Scholl/Wurzel 2002) and by the biotechnology promotion policy of Sachsen-Anhalt's government, too, were and are (necessary though not sufficient) key preconditions for the establishment and development of the regional innovation network InnoPlanta (cf. Conrad 2005).

4 Actor constellation and heterogeneous pattern of interests of the network

At the level of mainly corporate actors the actor constellation of the InnoPlanta network distinguishes itself by a clear involvement in the region, continuing engagement of its promoters, membership of interested service agencies, banks and public administration, support by (promoting) political institutions, cautious support by agricultural organisations, largely absence of opponents such as critics of gene technology, but also of global players in the agricultural, food and biotechnology industry.

At the individual level the actor constellation is mainly formed by an inner circle of 10 to 15 persons who occupy key positions in their respective (scientific, economic or political) institutions. As a community with a common purpose they attempt to get their varying interests and concerns taken into account with the help of InnoPlanta's development and orientation. Said interests consist of the acquisition of research funds, the profiling in economic policy, the establishment of educational infrastructure and study courses and finally strengthening one's position. Due to their professional positions and since they belong to the inner circle their (project) interests are more likely regarded than the ones of other members of the network who are less involved. For instance, the two key research institutions IPK Gatersleben

and BAZ (Bundesanstalt für Züchtungsforschung an Kulturpflanzen) in Quedlinburg (together) participate in more than half of all projects and receive about one third of all InnoPlanta research funds (Conrad 2005, Conrad/Steuer 2003).

Since the interests of the major (corporate) members of the network are mostly in line with each other (funding of, performing and economic viability of R&D plant biotechnology projects), they are rather compatible with the genuine interest of the network to successfully carry out such projects. Cooperation between different (research) fields and linking of differing R&D projects, however, received and still receive less support from the network members.

Manifest and latent conflict constellations mainly stem from procedural and (via bargaining) regulated conflicts about the distribution of resources and of corresponding decision competencies. The (above mentioned) structurally embedded conflict about research priorities led to acceptable solutions, too. In this context the small InnoPlanta secretariat provided an administrative forum for diverse networking activities, mainly to organise information flows and knowledge exchange, communication among network members, and project proposal procedures, to advise project proponents, to attract and convince new members, and to do public relations.

There is no opposition to and controversial internal debate about the utilization of genetic engineering in plant biotechnology within the network, although varying positions exist concerning emphasizing and focussing on it. In view of the in general disfavoured socio-economic situation of Sachsen-Anhalt the aim of and the belief in a future regional centre of plant biotechnology may well be helpful for the sustaining power and (economic) viability of InnoPlanta.

5 Innovation pattern and market perspectives of InnoPlanta research projects

The innovations in plant biotechnology by InnoPlanta members are frequently oriented towards niche markets concerning specific spice and herbal plants with well established regional expertise, since they take into account world market perspectives, and renounce the development of genetically modified food products.

The approximately 30 research projects, currently carried out by collaborative research groups from biotechnology science and industry, considerably differ with respect to the influencing factors such as project size, type of innovation strived for, market potential and market chances, GM product envisaged or not, economic consequences and social compatibility, or problems of social acceptance.⁶ As a consequence, these projects have to be investigated individually, and their chances of success or failure vary enormously.

Addressing in somewhat more detail (typical) R&D processes, orientations and market perspectives of these research projects, the outlet and differentiation of InnoPlanta's innovation strategies may be summed up as follows:

(1) Referring to future use and selling of project results, relevant framework conditions as well as the perspectives of the collaborators are clearly oriented towards the world market. This may concern potential future markets of Mykorrhiza granulates or competitiveness of thyme products on the home market against cheap import goods. Furthermore, with respect to research, development and patenting,

⁶ Sufficient understanding and assessment of the research projects requires rather detailed knowledge of their substance, design, development, actor perspectives and constellation, and structural contexts (cf. Conrad 2005).

the actors involved in the R&D projects know about similar projects and their differences all over the world.

(2) Due to the mainly small or eventually medium size of the regional companies involved, most R&D projects at least first aim at niche markets which are less attractive for large agrochemical or food corporations and allow for competitive advantages of specialised development competencies. Some R&D projects, however, aim at the development of basic platform technologies, such as Transgene Operating Systems of the biotech start-up Icon Genetics, which could be applied in plant breeding worldwide though typically in co-operation agreements with large biotechnology corporations. The biotechnological processes and products envisaged in the R&D projects of InnoPlanta are much less afflicted by global market conditions, trade conflicts and opposing interests (cf. Bernauer 2003, Kern 2002) than the production of genetically modified soybeans, rape, cotton and maize predominating in agrobiotechnology at present.

(3) The members of InnoPlanta took into account the currently disfavourable boundary conditions of green biotechnology, such as partly restrictive policy regulations, lacking acceptance of genfood by consumers, renunciation of genfood by most food corporations. Although nearly all members of InnoPlanta are in favour of green biotechnology they deliberately forwent to carrying out R&D project aiming at genfood products.

(4) There exist partly diverging interests and aims of the actors belonging or intentionally influencing the InnoPlanta network, such as basic research orientation versus market orientation, flexible research arrangements versus bureaucratic control schemes, differing time horizons of research, development and testing of new plant breeds, of market introduction and penetration, and of visible impacts of (technology) policy-making. Thus, the in-

tended strengthening of regional economic performance by the market penetration of newly developed plant biotechnology products or processes will most probably demand more time than required under ideal model network conditions.

The InnoPlanta R&D projects show considerable differences in several dimensions (cf. Conrad/Steuer 2003). Success and failure are both well possible and depend on the respective specific boundary conditions of the projects. Whereas the majority of the projects involves incremental innovations, particularly those focussing on new molecular genetic processes aim at radical or at least moderate innovations and at greater market potentials. Additionally, economic considerations do play a significant role in the projects, yet address differing aspects. In one case they led to the stop of a large project.

GM technologies are in the centre of some projects and avoided in other projects. Whereas most projects would lead to a competitive advantage of the plant biotechnology products or processes under development, their technical viability and thus their successful development cannot be taken for granted at all.

Consequently, innovation pattern and market perspectives of the InnoPlanta research projects may be summed up as follows:

- Most R&D projects will probably not reach the phase of successful market introduction. However, some of them will succeed in market penetration, most likely those addressing smaller market segments of spice or herbal plants, which usually are less interesting for large (multinational) corporations.
- Differentiation in innovation strategy (cf. Porter 1990, 1998) seems to be particularly advantageous for a regional research network lacking the market power of large transna-

tional corporations as influential global players.

- Induced by the innovative efforts of the network quite some improvement of the regional scientific, technical and economic infrastructure and framework conditions may well be reached with competent actors and networks for further economically viable activities in plant biotechnology. This would contribute to the socioeconomic viability of the region Nordharz/Börde, which offers rather low attractiveness compared to other regions of Germany, but has a long tradition in agriculture and plant breeding, on the one hand, and to environmentally friendly changes in agricultural and food production in some cases, on the other hand (Conrad 2003). It remains an open question if this would be sufficient to more or less generally secure its sustainability in economic, social and cultural terms.
- The reach of the innovations, particularly those promising ones addressing spice and herbal plants and their products, will remain a relatively limited one on average. Therefore future innovations (in plant biotechnology) may well be facilitated by this InnoRegio setting, but their substantial sustainability remains uncertain due to unpredictable changing framework conditions for research and development in a future more than 10 years ahead.

6 Structure and role of public promotion policy

Public promotion policy played and plays a decisive role in the formation and the development of the regional innovation network InnoPlanta. Without the (competition-based) InnoRegio program it would hardly exist, although its initiators possibly might have created a similar (smaller) association with start-up financing pro-

vided by the state government of Sachsen-Anhalt. Public support and funds (of 20 Mio. €) thus were a necessary condition for the stable formation and possible future self-supporting development of InnoPlanta.

The same is true for further (foreseeable) programs and measures such as the recognition of InnoPlanta as a competence network in biotechnology by the BMBF or the participation of InnoPlanta members in the biotechnology program of the state government of Sachsen-Anhalt, started in 2004 and providing 150 Mio. € over a period of five years. With this program it attempts to make the state a centre not only for red biotechnology, but for green biotechnology, too, in order to strengthen its economic development. In view of the projects which are typically profitable only in the long run, these promotion programs provide windows of opportunity for InnoPlanta. They offer the chance to acquire funds beyond the InnoRegio program for promising, partly already running R&D projects with the aim to develop marketable products or processes in plant biotechnology.

The options and measures of public policy to establish innovative regional self-supporting clusters – in the field of plant biotechnology – are limited and mainly concern the support of suitable regional boundary conditions and the provision of appropriate regulatory and communicative framework conditions (cf. Bröcker et al. 2003). Corresponding public policy measures exist to a considerable degree in the case of InnoPlanta. However, they can only enable but not enforce the formation of such a cluster because both, supporting as well as restraining factors, influence its sector-related, market-related, as well as regional socio-structural, socio-cultural and infrastructural preconditions. Accumulation of human capital, founding of new firms, significant competitive advantages by innovations, synergies by co-operation, venture capital by active

local firms are favourable sector-related preconditions. An expanding market for the products of the sector usually is a necessary market-related precondition for cluster formation (Brenner/Fornahl 2002).

Necessary regional preconditions, such as the existence of educational institutions, favourable attitude and possibility of local actors to found new companies, innovative capability of research institutions and of the population, have already been mentioned in section 1. Related factors in the case of InnoPlanta are the agrochemistry and the seed industry, which are highly concentrated at the global level, as well as the growth perspectives of plant biotechnology, which vary largely according to product groups. Additionally the political controversy about green biotechnology has to be mentioned, as well as the economic and social conditions at the national and regional level, which are currently unfavourable. Finally the innovation orientation of key regional actors and their capability to cooperate and to regulate conflicts, plays a major role. After all even the insufficient infrastructure and the low attractiveness of the region has to be mentioned.

The partly coincidental concurrence of four main policy objectives and programs were crucial for the favourable situation with respect to public promotion policy in 2000:

- Already since the 1970s technology policy in Germany classified biotechnology as key technology for Germany's economic competitiveness, leading to corresponding biotechnology promotion programs with continuously rising funding budgets.
- Since the 1990s technology, innovation, economic and regional policies increasingly aim at and support – by rather complex policy programs – the development of regional innovation networks and clusters which shall thereby gain a

self-supporting innovation dynamics and thus economic competitiveness and attractiveness.

- Also since the 1990s diverse promotion policy programs and financial transfers are pursued to rebuild deficient infrastructure and competitiveness of a declined economy and science in the eastern German states. The InnoRegio program, developed in this context, combines the promotion of these reconstruction efforts with an innovation policy aiming at regional cluster formation.
- The biotechnology program of the state government of Sachsen-Anhalt, started in 2003, has the same objective, but also reflects desperate measures and attempts at profiling to secure political legitimacy in view of the desolate situation of state economy and public budgets.

Concerning their substantive effectiveness two features of these promotion policies remain doubtful. On the one hand there is a rather rigid emphasis particularly in the ideological framing on mere economic procedural and evaluative concerns regarding their implementation, reflecting currently prevailing policy orientation towards short-term market success to secure legitimacy. On the other hand there are contradictory objectives of regulatory and promotion policies in (plant) biotechnology, hardly avoidable in the context of political controversy over green gene technology.

Summarizing, the substantive structural features of public promotion policy in the InnoRegio program consisted and still consists of a competition for R&D funds, initiating regional network formation, and the distribution of funds for R&D projects based on research cooperation over a period of six years. The selection of project proposals took place in a multi-step process by the network board itself, by a mixed promotion management team,

consisting of representatives from the network, the research management body Jülich, and state officials, and – as a veto power – the research management body and the funding ministry.

Although the InnoRegio program ended in 2006, further promotion programs of the BMBF are likely and also justified in view of the only long-term achievable profitability of most plant biotechnology R&D projects pursued.

Referring to the necessary positive interaction dynamics of favourable factors determining the success of the InnoRegio program, it is based on the mutually adjusted utilisation of the following instruments: First of all the fixing and operationalisation of quality goals as well as competition, incentives and agreements on objectives by the participants. Furthermore, measures are taken to realize the objectives from bottom-up, and monitoring efforts to analyse development processes and the effects of measures taken (Müller et al. 2002: 134).

Apart from a rather limited selectivity in project selection and, in the beginning, administrative problems of program implementation, leading to delaying and discouraging effects, public promotion policy clearly had a strongly promoting impact on the development of the regional innovation network InnoPlanta and thus largely fulfilled its political purpose and intention.

The InnoRegio program was a complex extensive (and experimental) policy program of the BMBF. Furthermore, it combined within one ministry different policies addressing research, technology, innovation, economic and regional development, which are mostly pursued separately, and thus had a rather coherent character.⁷ However, these qualifications do not necessarily

hold for the coordination of different policies pursued at different (state, federal, EU) policy levels of promotion policy because corresponding coordination efforts are largely missing.

7 Comparison of promotion objectives with achieved results

When comparing policy promotion objectives with results actually achieved, three distinctions have to be made in order to arrive at clear-cut conclusions in that respect. First, the effects of the InnoRegio program as a whole on regional scientific and economic development have to be distinguished from those on InnoPlanta and the region Nordharz/Börde, which are of interest here. Second, the achievement of short-, medium- and long-term objectives of the program may well differ and the latter ones cannot yet be evaluated at present because they can only be observed in about the next decade. Third, various objectives, such as the cooperation of regional actors, the degree of networking, creation of regional identity via networking, mobilisation of additional (economic) development impulses, may be envisaged but may be achieved with differing success.

The evaluation of these developments is based on a systematic (accompanying) study of the effects of the InnoRegio program (BMBF 2005) as well as on a detailed case study of InnoPlanta's development, including the role of promotion policy (Conrad 2005). The combination of both studies allows to give relatively clear-cut answers to the question if and to which degree (federal) promotion policy achieved its objectives. Knowing that InnoPlanta is a rather positive example among all InnoRegios promoted, the general, partially cited qualifications in BMBF (2005) can be assumed to hold for InnoPlanta, too.

The *short-term objective* of the InnoRegio program is the establishment

⁷ In its starting phase it was – in financial terms – the most extensive promotion program of innovation policy for the eastern German states (BMBF 2005: 19).

of viable regional innovation networks, i.e. bringing together regional competencies for the common work on promising innovative projects.

The *medium-term objective* is the improvement of the performance capacity of the network members so that innovation processes are facilitated and their innovative capacity is enlarged, finally leading to an increase in their economic performance.

The *long-term objective* is the strengthening of the regional economy as a whole so that the strengthening of actors, together with other direct or indirect effects of the InnoRegio program leads to economic growth impulses in the region (BMBF 2005). With growing length of time, the relative importance of promotion policy decreases compared to other influencing factors due to longer cause-effect-chains.

Improvement of scientific and economic capability can rarely be attributed unequivocally to one specific variable, such as a policy program or activity. Likewise the success of any policy promoting innovation projects depends on the fulfilment of preconditions, such as a corresponding performance potential of companies and realisable projects sustainable in the future. Taking these aspects into consideration, the (possibly) observed correspondence of promotion objectives and achieved results indicates a successful promotion policy, but does not actually prove it.

With these caveats the following empirical assertions can be made about the effects of the InnoRegio program on InnoPlanta and corresponding development of the region Nordharz/Börde:

Short-term objectives

Cooperation of different regional actors was successfully induced, although InnoPlanta only very gradually was changing its character from a pork barrel into an innovation network, and

cooperation mostly remained limited to specific projects with few participating actors, respectively.

Medium-term objectives

This cooperation tended to have positive effects on the innovation potential of the companies involved and also led to first successes in project-specific innovation processes.

Long-term objectives

Furthermore, intensified communication and exchange of services and activities tended to induce positive economic impulses for the region. Finally, the InnoRegio program induced a limited self-dynamics of the newly founded InnoPlanta association. This resulted in further mobilisation effects necessary to support its self-sufficient continuation after the end of the InnoRegio program, which can be observed at least in early 2007.⁸ So whereas technology and innovation policy induced the establishment of a regional innovative network in plant biotechnology, achieving subsequent successful cluster formation still remains an open question for the future. However, this was no direct aim of the InnoRegio program.

⁸ For evaluating the effectivity of the InnoRegio program key criterion is the durability of the processes of networked innovative development induced by this program. Here, the preliminary results are discrepant because the members of the various InnoRegios are sceptical about their chances to continue their R&D work after the end of its funding, on the one hand, but there is a general interest in most cases to further participate in the newly established network and to continue the cooperations initiated, on the other hand. In particular, the size of new product value chains generated can be reasonably assessed only if the results of the R&D projects will be successively transformed into new products so that product inputs will be increasingly demanded by enlarged production. In addition, establishing regional product value chains by corresponding innovation networks is limited by their objectives, actor interests and economic reasons (BMBF 2005: 8, 57, 71).

In sum, the short-term promotion objectives were reached to a considerable degree, and there are some indications that the medium-term promotion objectives may be at least partially reached as well. Whereas the efficacy of the InnoRegio program – after some likely initial difficulties⁹ – plausibly appears to be given for InnoPlanta and also in general, as confirmed by the perception of the InnoRegio participants (Eickelpasch 2004, BMBF 2005), its efficiency still cannot be judged because of lacking empirical criteria and comparable cases.

8 Conclusion

Putting together the insights gained from the case study and from the general analysis of promotion policy the following conclusions can be drawn concerning successful promotion policy in the case investigated and in general.

(1) At the conceptual level, technology policy combined three objectives from the InnoRegio program: to promote industry-oriented and marketable technological trajectories in the eastern German states, to rely on regions as self-organising and self-supporting actor constellations for the development of marketable key technologies, and to stimulate interregional competition for funding, technological pioneering and potential lead markets.

(2) As with other technology promotion programs, within the framework of the InnoRegio program technology policy can only provide favourable framework conditions and incentives, as well as initiate significant action and influence the basic development orientation of a regional innovation network. Its actual development, how-

ever, apart from the public funding provided depends on the resources, the capacity for action and the self-interests of a region, shaped by the availability and interests of (regional) promoters, overcoming problems of network formation, and resulting social and technological path dependencies. So technology (promotion) policy – even if specified towards regional circumstances – has very limited possibilities to steer technical innovations. Once a project has been accepted for funding technology policy can hardly substantially influence its further development and success. If a project or an InnoRegio finally will be economically successful is not within the reach of innovation policy.

(3) Increasingly, technology policy is making an effort to evaluate its own programs by accompanying research. However, it remains an open question if the results of this research in fact influence actual and future policy programs accordingly.

(4) Different from many other policy fields technology policy may follow necessary long-term perspectives although the success of corresponding policy programs remains more open than those in other more short-term oriented policies. Because of the strong economic application and market orientation of the InnoRegio program, such a long-term perspective of one decade or even more may be easily undermined politically.

It is worth noting that technology policy continued this promotional policy approach in later programs, such as "Interregional alliances for future markets (innovation fora)" or "Innovative regional growth centres".¹⁰

Altogether, it is reasonable to conclude that technology promotion policy fully utilized its limited potentials with respect to the self-defined objectives of

⁹ Frequently, the networks and their actors underestimated the task to transform their ideas in substantive R&D projects qualified for funding, and lacked experience concerning public funding procedures and cooperation in networks (BMBF 2005:19).

¹⁰ "Interregionale Allianzen für die Märkte von morgen (Innovationsforen)" and "Innovative regionale Wachstumskerne".

the InnoRegio program. Apart from initial practical difficulties in particular for the InnoRegio InnoPlanta it realized, its underlying conceptual approach in a well-reasoned manner.

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